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INTENSIVE STUDIES OF LOCAL CONDITIONS AS AN AID TO FORECASTING FIRE WEATHER.[1]

By George W. Alexander.

[Weather Bureau Office, San Francisco, Calif., Sept. 19, 1923.]

As is well known, certain meteorological conditions are exceptionally favorable to the inception and the spreading of fires in the forested regions of this country. These conditions, although varied and due at times to somewhat different causes, have come to be known, for lack of a better term, as "fire weather." Research and analytical studies of the data accumulated during a period of years, by members of the Forest Service, have shown that fire-weather types may be somewhat roughly divided into three classes, namely:

1. Conditions actually causative of fires, that is, storms accompanied by lightning.
2. Conditions favorable for the inception of fires, however caused; these are marked by periods of unusually low absolute humidity and high temperatures.
3. Conditions favorable for the spreading of small fires, and the passing beyond control of larger ones; that is, desiccating winds and other winds of from moderate to high velocities.

Any one of these three conditions may occur singly, or a combination of any two or all three may add to the difficulties of the situation.

The three classes do not include the cumulative effect of the generally high temperatures, light precipitation, and low humidities of the summer months, which reaches its climax in maxima of fires and of damage therefrom during August or September, inasmuch as the results of such conditions are patent to the observation of all concerned, are of annual recurrence, and should require no specific forecasts. This seasonal increase in the fire hazard is, however, of prime importance to the extent by which it increases the possibility of danger during the occurrence of any or all of the specific classes of fire weather.

It is the belief of representatives of the various forest conservation associations of western America and of those members of the Forest Service who are engaged in the investigation of the problems of fire prevention and fire control that forecasts of the fire-weather conditions noted above would be invaluable could such forecasts be made sufficiently accurate and be localized to such an extent as to justify reliance on them in guiding the mobilization of the fire preventive and suppressive forces of the forestry organizations, with a view to minimizing the damage resulting from such fires as may be unavoidably caused either by natural forces or by human agencies.

Forecasts for fire weather have heretofore been and are now being made by officials of the Weather Bureau, and such forecasts have undoubtedly been of a certain value. But the meteorologist knows that the reliability of a forecast depends on the amount and accuracy of the information as to prevailing conditions that is set before its maker, and that for its localization it is necessary that conditions in the actual area under consideration be known, and that by previous study such conditions be correlated with the effects of the general distribution of the elements that control the weather.

At present the forecaster has before him a synoptic weather map which shows conditions as they exist at the several stations of the weather services of the United States and Canada, and at such positions on the seas as may be indicated by reports from such vessel weather stations as are within communicating range. Most of the land stations are at a considerable distance from each other, some separated by hundreds of miles. They are located, as a rule, in centers of habitation, generally in cultivated valleys or along the coast, for the most part where artificial, rather than natural, conditions obtain. Hence the reports as to temperature, wind direction and velocity, and precipitation, as they appear on the map, are not truly representative of those conditions that exist in the forested areas. While the pressure distribution is shown as accurately as possible, taking into consideration the reduction of the observed readings of the barometer to a sea-level basis, there is still a possibility that there may be local variations in pressure sufficiently great to influence local conditions, in the spaces between stations, which do not appear on the map. Hence the sectional forecasts for wind directions and force, while justified in general, may be altogether inapplicable to a certain specified forest therein. For the forest areas are, as a rule, located on the rugged slopes of the great mountain chains of the West, and in the intervening valleys, at elevations varying by thousands of feet. As is known to the most casual investigator, topography influences local weather conditions by its effects on the surface air currents and on the temperature of the air itself almost in direct proportion to its diversity and ruggedness. All of which adds to the difficulty of the forecaster's problem, that of indicating specific conditions in a limited locality from information of a very general character.

A somewhat similar condition for a long time obtained in the matter of forecasting frost, or damagingly low temperatures, for the benefit of those fruit growers who practice orchard heating during the winter and spring months. But this problem has been quite successfully attacked, and a high percentage of accuracy in forecasting minimum temperatures and the hour of occurrence of damaging temperatures has been obtained in several districts in California, Washington, Oregon, and elsewhere. Intensive studies of local conditions, made by trained observers, have been the means to this end. The forecast for temperature that is issued to interested parties in the fruit-frost districts does not depend only on conditions as they are shown on the general weather map, but is modified

[1] Presented at meeting of American Meteorological Society at Los Angeles, Calif., Sept. 19, 1923.

by what the field observer has learned of the peculiarities of the local situation and their relation to the general scheme of things. And it has been found, during this frost work, that local topography, by its influence on air currents and humidity, causes changes in local conditions to such an extent that widely varying forecasts are sometimes required for two almost contiguous sections, and that within a section points but a few miles distant from each other vary greatly as to minimum temperatures, according to their relative situation. The forecasts are becoming more reliable from season to season with the collection and analysis of additional data.

While the analogy between forecasting minimum temperatures and forecasting fire weather is by no means complete, it is sufficiently so that in studying the problems arising under the latter head the query naturally arises, "Will not a somewhat similar method of attack produce similarly favorable results?" And the conclusion is that there exists so much of a possibility of favorable results that to make the experiment is well worth while.

Thanks to the researches of various members of the national Forest Service we know exactly what we wish to attempt, which simplifies matters considerably. That is, we desire to forecast thunderstorms, both local and general, and to determine in advance, if possible, the probability of comparatively light or heavy precipitation accompanying a given storm; to forecast, a day or so in advance, a period of unusually low humidity with its consequent lowering of the moisture content of the duff and litter of the forest floor; and to predict reliably the changes in force and direction of the winds in the different sections of the forest.

There is reason to believe that, with sufficient local data to supplement that of the general weather map, such results may be accomplished, in certain areas at least. This may not be possible during the first season's work, but should be within a reasonable time, for much observational and analytical study of the topographical and meteorological peculiarities of the regions involved will be entailed, all of which will require time and patience.

A tentative outline for such a project has been prepared. Whether or not it can be put into operation depends on the appropriation of the funds necessary for procuring the required instrumental equipment and defraying the expenses for salaries, transportation, and the like, incidental thereto. Considerations of economy will also dictate that until the feasibility and value of such an undertaking have been fully determined the experiment be limited to three or four selected areas, which would undoubtedly be those concerning which the greatest amount of information is now available, and where there may be the greatest possibilities of cooperation between the workers of the Forest Service and those of the Weather Bureau.

To inaugurate such a survey will be no light task. It will require the services of at least one trained meteorologist in each area, supplemented by the assistance of local members of the Forest Service or such others as may be available.

Aside from the more immediate results of a comprehensive series of meteorological observations in the forest that may be expected from such a course, a wide and fascinating field of study is opened. The greatest single cause of forest fires is lightning. Lightning fires vary in number from year to year but for one decade in California, as stated by Messrs. Show and Kotok in their very comprehensive paper on forest fires in California for the period 1911–1920, they aggregated 41.5 per cent of the total number of fires. Such fires are the result both of local storms, most numerous in certain areas that have been tentatively defined by these investigators, and also of the general storms that cross the continent from west to east. Individual storms of the latter class have at times been responsible for great numbers of fires scattered over a wide area—over 300 per storm having been recorded on at least two occasions—with a consequent overtaxing of the fire-control system of the Forest Service and proportionately great public loss, both in the cost of control of the resultant conflagrations and in the value of the timber destroyed. Here we have a pressing incentive to the detailed study of such phenomena, so that we may devise means of giving sufficient warning to the responsible services that fire preventive and suppressive forces may be mobilized in time to minimize the damage from such fires, as their prevention, naturally, is not possible. We have ample information as to the origin and causes of thunderstorms and the weather types during which they are most common. It therefore seems quite within the realm of possibility that, having adequate local data as to air movements and humidity, together with the general information afforded by the synoptic chart, we may determine that certain combinations of conditions will or will not result in thunderstorms over a given area, this some hours in advance of the actual occurrence and with a sufficient percentage of accuracy as to be of value to those concerned. Also, perhaps somewhat later, the determined moisture content of the lower air mass and the direction of the currents, with a detailed knowledge of the changes to be expected from the predetermined movements, may enable us to make a very fair forecast as to the relative amount of precipitation to be expected from a certain storm, that is, whether comparatively light or heavy over the different topographical sections of the area over which it passes. The value of a forecast of this nature, if such be found feasible, is obvious.

That combination of conditions giving us the second general type of fire weather, namely, low humidity and high temperatures, is also, in its local manifestations, the result of a combination of general pressure distribution and the influences of local topography. Given the records from a season or two of such observations as have been described and to my mind the possibilities for an accurate 12 or 24 hour forecast of these factors are most favorable. First, curves for humidity and temperature vary, in a fashion well known, during the change from the predominating influence of a HIGH to that of a LOW. This would give a working basis. To forecast ensuing maxima, with the aid of the weather map and of hygrometric formulæ which may be developed should not be unduly difficult. Here it may be said that hygrometric formulæ of real merit have been developed at widely distant stations on the Pacific coast for use in conjunction with other data available in forecasting maximum and minimum temperatures. Given, then, the expected maximum, accurate to within two or three degrees, and the necessary information as to the distribution of the centers of high and low pressure and their movements, it should be feasible to produce a curve of the expected humidity. For this factor the absolute humidity, as expressed by the vapor pressure or the temperature of the dew point, would have to be used, as tending toward a more even curve than would the percentage of relative humidity, which fluctuates so greatly with changes of temperature.

Or the evaporation factor may be used as the basis of the curve. Inasmuch as intensive investigations are at present being carried on by the Forest Service as to the

relation between atmospheric humidity, as expressed by the rate of evaporation, and the moisture content of the duff and litter of the forest floor, the development of reliable forecasts of evaporation rates would be highly desirable. It is realized, of course, that evaporation is also affected greatly by the winds, so that any attempt at such a forecast would have to take into consideration the expected velocity of the air currents, their direction, and the nature of the terrain whence they come, as affecting their moisture content. Truly a complex enough problem, at first sight, but one which may well be solved—given the time and means for the proper study of its constituent factors.

On looking into the problem of forecasting the third type of fire weather—that is, winds favorable for the spreading of fires already in existence—we also find an amply complex situation. To the effects of the distribution of the centers of barometric pressure we must add the opposition to the general air movement that is afforded by the inequalities of local topography, the effects of sharp differences in temperature over contiguous areas, and the diurnal changes caused by convection during the day and the descending hill or mountain breezes at night, and, also, the intense convection caused by a widespread fire, if such be in progress. Having the weather map, however, and a thorough knowledge of the locality under consideration, the forecasting of winds should present no insurmountable difficulty.

In speaking of the use of formulæ and curves as aids to forecasting one does not wish to imply that they are by any means infallible. When properly produced, however, from reliable data, they do become of use in the delimitation of what may be expected under normal conditions. The forecaster must also take into consideration all attendant circumstances that may come or be brought to his attention, from all sources available, and then employ both his judgment and his intuition. Nor is it desired to convey the impression that completely reliable forecasts can be made from the moment that the collection of local data is begun. The number and variety of the forces that affect the weather and the difficulty in securing adequate information in advance must be considered. Time will be required for the collection of the required data and for its study and correlation.

A very general statement only of what may be attempted has been made. It would be useless and somewhat difficult to go into more specific detail. But, knowing what is required and what he must try to accomplish, and with a well-defined idea as to methods, the individual investigator will have to adapt his resources to the particular problems presented by the area to which he is assigned. And it is hoped and expected that through the cooperation of the local observer, the district forecaster, and the members of the Forest Service, the accuracy and timeliness of forecasts for fire weather may be greatly improved.

RELATION OF WEATHER FORECASTS TO THE PREDICTION OF DANGEROUS FOREST FIRE CONDITIONS.[1]

By R. H. Weidman.

[Priest River Experiment Station, United States Forest Service, September 10, 1923.]

The purpose of predicting dangerous forest-fire conditions, of course, is to reduce the great cost and damage caused by forest fires. In the region of Montana and northern Idaho alone the average cost to the United States Forest Service of fire protection and suppression is over $1,000,000 a year. Although the causes of forest fires will gradually be reduced by education and law enforcement, there always will be forest fires started by lightning and other causes when conditions in the forest are dangerous. If the dangerous fire conditions, however, can be predicted a few days in advance, the fire-protection organization can be prepared to find and suppress fires when they are small and easy to control.

To predict dangerous fire conditions in the forest, it is necessary to know exactly what constitutes such conditions. The material in the forest which burns is of first interest. Taking wood as a fuel, it is clear that if wood is dry it burns readily; if it is wet it does not. The important factor in this case, therefore, is the moisture content of the materials which comprise the fuel of forest fires. Thus, if the forester knows the different degrees of inflammability of the fuel in terms of differences in its moisture content, it is possible for him to state definitely for to-morrow or the next day what influence the approaching weather will have in making it drier or wetter; in other words, more inflammable or less inflammable.

The moisture contained in duff and other débris on the forest floor is influenced, of course, by various weather elements. The materials absorb moisture chiefly from the atmosphere in the form of rain and humidity. In summer it is largely the relative humidity of the air which causes changes in the moisture content of the materials. Duff, which is the layer of matted needles on the forest floor, especially responds to the changes in relative humidity. With high relative humidity at night the duff is relatively damp; with low relative humidity in the daytime, it becomes dry. When the relative humidity is consistently low for several days in succession, the duff loses more and more of its moisture—sometimes, in the white pine forest of northern Idaho, dropping to as low as 3 per cent of its oven-dry weight.

By inflammability tests it is known that when moisture content of duff in this region is about 10 per cent the material is readily inflammable. Below this moisture content it is extremely inflammable; above it, it gradually becomes less inflammable until a moisture content of about 17 per cent is reached, when it is difficult for a camp fire to spread readily in this material. When duff has a moisture content of 25 per cent it would be difficult for large forest fires to spread.

As relative humidity is the most important factor in changing the inflammability of forest materials in summer, the question may be asked: "Why not use relative humidity as an index?" The answer is that relative humidity does not always indicate moisture content consistently for the reason that changes in moisture content of woody materials lag behind changes in relative humidity of the air. Another disturbing element here is temperature of the air. In nature the three elements—relative humidity, temperature, and moisture content of materials—are rarely in equilibrium. Moreover, there is an infinite variation in their relations, as a result of not being in equilibrium. A few actual measurements will illustrate this better than words. The first part of the following tabulation shows the temperature, relative humidity, and existing moisture content of duff as measured at the Priest River Experiment Station; the second part shows the moisture content of wood in

[1] Presented at meeting of the American Meteorological Society at Los Angeles, Calif., September 19, 1923.

equilibrium with corresponding temperatures and relative humidities as measured under controlled conditions at the Forest Products Laboratory.

Duff.

Relative humidity.	Temperature.	Moisture content.
Per cent.	*Degrees.*	*Per cent.*
25	92	14
29	77	9
56	77	14
70	75	10

Wood.

Relative humidity.	Temperature.	Moisture content.
Per cent.	*Degrees.*	*Per cent.*
25	92	5
29	77	7
56	77	10
70	75	13

Thus it is seen that relative humidity one day may be 25 per cent and the moisture content of duff 14 per cent. The next day the relative humidity may be 29 per cent and the moisture content only 9 per cent. This sort of variation, when it occurs near the danger line of inflammability, as in this particular case, is a very important factor in predicting dangerous fire conditions.

At the Priest River Experiment Station, therefore, moisture content is used directly as an index of inflammability. As the top layer of duff is the material which carries fire through the forest, it is the one which is chiefly concerned in predicting dangerous fire conditions. This is true in the virgin forest with which the Forest Service in Idaho and Montana is mainly concerned in fire protection. In order to measure the moisture content of duff in place, a recently developed duff hygrometer is being used at the experiment station. The instrument consists of a hollow, perforated metal tube containing a strip of rattan which expands and contracts with changes in moisture content and so arranged as to register the changes on a dial attached to one end of the instrument.

Knowledge of the existing moisture content of the fuel, and therefore its existing condition of inflammability, is one of the requirements necessary for making a prediction of inflammable conditions in the forest. The other equally important requirement is a thorough weather forecast, in order to know whether the forthcoming weather will bring conditions making for greater or less moisture in the atmosphere and thus greater or less moisture in the fuel. The weather forecast, of course, should be of such a nature as to give this information—whether the changes in the moisture of the atmosphere are to be influenced by rain, temperature, cloudiness, or other elements.

Although relative humidity is the most important factor involved in the moisture content of the débris on the forest floor, it is not by any means the only factor which must be taken into consideration. Without going into the subject too deeply, some of the other factors may be mentioned. For instance, the duff moisture contents resulting from various amounts of rainfall must be determined. The rate of drying out of duff and other materials after receiving various amounts of rain must be known. The effect must also be known of a given quantity of rain occurring in one hour, for example, as compared with the same quantity occurring evenly distributed through a much longer period. What is the relative amount of rain reaching the duff through the forest canopy as compared with that falling freely to the ground in the open? What, under various conditions, is the effect of temperature, humidity, and wind velocity in the drying out of duff after a rain? What are the moisture contents of duff, twigs, branches, down logs, and such materials, under all the possible combinations of temperature and humidity commonly experienced during a fire season? And so on.

It is desired to point out, in closing, that the weather forecast and the existing condition of the fuel are both necessary in predicting dangerous forest fire conditions. Weather forecasts in themselves are not sufficient as fire warnings; nor are the records of measurable conditions on the ground alone sufficient. The Forest Service can determine the prevailing conditions of inflammability, but is dependent on the trained meteorologists of the Weather Bureau for accurate and complete forecasts of what the weather is to be. It is realized that it is exceedingly difficult to make the sort of detailed weather forecasts that are needed. In this connection, Mr. Beals stated in a recent article in the MONTHLY WEATHER REVIEW:

> The making of reliable fire weather warnings is even more difficult than the making of frost predictions; and in the latter case it has been proven that the most satisfactory method is to obtain all the information possible regarding the past weather, and then have a man on the ground capable of amplifying a general forecast to meet the conditions over a small area.

This suggests the possibility of having a meteorologist of the Weather Bureau on the ground to work side by side with the men of the Forest Service who are conducting the fundamental fire studies in several localities in the West. So far as the prediction of dangerous fire conditions is concerned, it is believed that this would be one of the most effective ways in which the Weather Bureau could help in the solution of the forest fire problem.

FOREST FIRE WEATHER IN WESTERN WASHINGTON.

GEORGE C. JOY, Chief Fire Warden.

[Washington Forest Fire Association, Seattle, Wash., September 15, 1923.]

In discussing the subject of forest fire weather in western Washington, I will take up only that phase of the weather which is the cause of crown fires in the Douglas fir region of our State.

The localities which are susceptible to such fires are the Douglas fir and white pine regions of North America. The Douglas fir region is located between the forty-third and fifty-third degree of North latitude; the summit of the Cascade Mountains on the east and the Pacific Ocean on the west. The center of this zone north and south is near latitude 47° north. The zone comprises an area approximately 650 miles long by 150 miles wide.

In the white pine region the conflagration zone is central along latitude 47° north from the foothills of the west slope of the Rocky Mountains to the Gulf of St. Lawrence.

During the past 100 years 15 great fires, of which we have more or less record, have occurred in these two regions. Six of the 15 fires referred to have occurred in the Douglas fir belt during the past 50 years. One who is

familiar with the lore of the fir region can find chronicled therein other great fires dating back beyond the discovery of America.

Our fir forests grow and thrive under the normal climatic conditions peculiar to the North Pacific coast region west of the Cascade Mountains. The whole region is wet; the prevailing westerly winds carrying the moisture in from the ocean, where it is condensed by the chain of high mountains and falls on their western slope.

As long as normal weather conditions prevail, the summer season is marked only by fires that are local in their character; their spread being due to diurnal convectional disturbances of the atmosphere, to local winds, or to a rough topography. Such fires are usually confined to small areas, and, as a rule, they are not difficult to control. I do not wish to minimize the danger from such fires, for occasionally they do considerable damage before being brought under control and they form the nucleus for larger fires.

It is when the *normal weather* conditions are jostled out of their equilibrium and the Douglas fir region is flooded with the hot dry air from the arid regions of the western part of the United States and Canada that the forest fire peril becomes imminent and fires are immediately fanned out of control, sweeping irresistibly over vast areas without regard to the topographic nature of the country. When this occurs, man is powerless and only a change in the wind will avail to stop them.

The fact that not more than six great fires have occurred in the fir belt during the past 50 years will give one an idea of the irregularity and infrequency with which they occur. Our fir forests are here because of this fact. No doubt such periods of fire weather have occurred more often than the foregoing record would indicate, but they have passed unnoticed for the reason that at the time of their occurrence no fires were started where they would sweep over and destroy large bodies of timber. *It should always be kept in mind that it takes two things to cause great forest fires, viz, the right condition of the weather and a fire in the right location.* Such a combination has not often occurred in the past, but the prospects are that it may occur more often in the future. Weather conditions will continue as they always have, but the chances of fire being started have increased a thousandfold. The potential danger is increasing and the possibilities are that some day the Douglas fir region will be devastated by a conflagration far surpassing any such disaster of the past. The stage was set for such a climax on August 1, 1922, but it did not occur as the right kind of weather did not materialize.

What element is it that causes such a disturbance in our normal weather conditions; that changes an easy fire situation into an alarming dangerous one overnight? For that is what does occur.

In the MONTHLY WEATHER REVIEW of February, 1914, Mr. E. A. Beals, then in charge of the Weather Bureau office at Portland, Oreg., discussed the value of weather forecasts in the problem of protecting forests from fire. Since that article was written we have had time and opportunity to study and observe the effect of weather conditions as affecting fires. The result of these observations and of our experiences have been such as to convince us that Mr. Beals's statements and conclusions were correct in every particular.

All of our trouble comes to pass when a high and a low pressure area are in such relation to each other as to cause the wind to blow across western Washington from off the high arid regions of eastern British Columbia, eastern Washington and Oregon, southern Idaho and Utah.

A glance at the charts of the normal relative humidity of the United States for the summer months shows the lowest humidity to be in the great basin situated between the Cascades and Rocky Mountains, and extending from Arizona to central Idaho. The altitude of this region is from 2,000 to 4,000 feet.

When a high pressure area is in the right position, it causes the wind to blow off this region toward western Washington. This wind is hot and dry when it begins its journey and in its ascent to the east slope of the Cascade Mountains decreases in temperature at the well-known rate of 1.6° for every 300 feet of elevation. In its descent of the west slope it increases in temperature at the same rate, but it descends so much lower than it ascends that its temperature at tidewater is considerably greater than it was when it began its journey westward. As a result its capacity to absorb moisture has increased at an increasing rate, and this is why a fire which to-day is docile and easy to control, breaks all bounds on the morrow and sweeps irresistibly onward over valleys and hills, leaving death and destruction in its path. Such a situation is brought about by the desiccating effect of these winds. If this condition of weather prevailed over western Washington for only the summer months, there would be no Douglas fir region.

The abnormal condition is brought about by the development of a high pressure area in Alaska, British Columbia, or the North Pacific Ocean. Trouble begins immediately when this HIGH starts on its journey southeasterly across the States of Idaho, western Montana, Utah, Wyoming, and Colorado. Coincident with this movement, a LOW develops in southwestern Arizona and usually advances northward through central California, up to Sacramento Valley, and breaks over the barrier of mountains at the California-Oregon line, flooding western Oregon and Washington, and often extending into British Columbia.

The first effect of the HIGH is felt when it appears north of the Canadian border. Northerly and northeasterly winds are prevalent. As these are descending air currents from over a hot, dry land surface their desiccating effects are soon felt. As the HIGH advances to the southeast, these descending air currents, which flow spirally outward clockwise, cause the wind to veer and come from a more easterly direction. It keeps on changing its direction until a southeasterly course is reached, when a HIGH usually disappears and the atmosphere begins a new formation of its forces.

The severity of such a spell of weather is dependent upon the relative position the HIGH bears to the LOW; the difference in the extremes of pressure, and the length of time the HIGH takes in passing.

It will be observed that the winds are first northerly, veering to the east, and then coming from a southeasterly direction. A glance at the temperature and humidity charts of the western part of the United States will serve to demonstrate why, when the wind is from a southeasterly direction, our fire hazard is greatest. All of our large crown fires—real conflagrations—have spread in a northwesterly direction.

Humidity of the air is determined by the temperature, distance from the ocean, the inclosure of mountains, and the altitude. All of these factors are present in the direction from which our southeasterly winds blow.

One of these spells of weather occurred from May 26 to June 4, 1922. On May 26 and 27 a large HIGH appeared in southern British Columbia. At the same time a LOW developed in southern New Mexico and southeastern Arizona. On May 29 the southern end of the HIGH was

central in northern Montana, and the LOW had advanced to southwestern Arizona.

On the 31st the HIGH was central over southeastern Montana, and the north end of the LOW had advanced up the coast to Vancouver Island, and seemed to be central in the Pacific Ocean just off the entrance to Grays Harbor. The isotherms on the weather map for that date show that the highest temperature in the western part of the United States was a spot about 70 miles in diameter on Grays Harbor. At Seattle the temperature jumped to 89°, and at Aberdeen to 93°; both abnormally high for western Washington. The prevailing winds were southeasterly, and in some localities were very strong. The relative humidity went to 21 per cent.

The fires which had been fanned into life during the preceding six days now became uncontrollable. One fire covered 25,000 acres, and destroyed more than half a million dollars' worth of property in an afternoon. This happened six days after a heavy rain had fallen, with all forest material soaked through and through. But these six days had been hot, windy, and dry. The moisture evaporated from the moss on the trees, the leaves and scaly bark; the feathery rotten wood on dead trees; the resinuous spills on the branches; the dead ferns and fireweed; all these became as tinder.

It is worth while to note that this HIGH rotated clockwise; that its nose first pointed southeast on the 27th, on the 29th it was a little to the southwest, on the 31st the elongation was southeast and northwest, on June 1 it had rolled northeasterly, and on June 5 had completely disappeared. It had occupied 10 days in passing—an unusually long time. Its strongest effects were felt when it was central over southeastern Montana and northeastern Wyoming.

At the time of the great Columbia fire, on September 12, 1902, the HIGH and the LOW occupied the same relative position to each other.

As soon as this HIGH disappeared, the weather conditions in western Washington immediately became normal; fires died down, were easy to control, and ceased to run.

Right here I want to emphasize the statement that the danger of a conflagration is just as great—and it as frequently occurs—in the spring of the year, when all forest material is damp and wet, as in the autumn following a dry summer. The rapid heating of the atmosphere in the spring as the sun advances north gives the air a greater capacity to absorb moisture than in the fall when it is cooling off

All of the large fires in the Douglas fir region are caused by descending winds blowing outward from a HIGH.

In his discussion of the subject, Mr. Beals states "that in the case of the Michigan fires, and the Hinckley fire in Minnesota, the air currents were ascending and blowing inward toward a LOW."

I have not given this phase of the subject sufficient study to warrant me in making a statement as to why such a condition should cause great fires in one locality and not in another, but in passing I want to venture a guess on the matter, and that is, that it does not make any difference whether the wind is blowing from a HIGH or backing into a LOW—the effect is the same if it continues any length of time to come off a hot, arid land surface.

It would seem to me that the study of fire weather forecasts should include a close observation of what is taking place in Alaska and British Columbia, as there is where our trouble seems to develop. I will have to leave the question as to why the HIGH develops up there to the technician who understands that phase of meteorology. I am more concerned about where they go when they start wandering away from home.

From my own observation it would appear that an intensive study of the actions of these HIGHS by the United States Weather Bureau, supplemented and correlated with similar work done by our Canadian brothers, who are as vitally affected and interested in the subject as we are, would lead to a knowledge of the atmospheric disturbances which is the cause of all our trouble.

We need men versed in the technique of meteorology, who can give all of their time and attention to a study of the relationship of changes of weather as affecting forest fires. In order to render a maximum of help, they must, during critical periods of weather, be on the job night and day—Sundays and holidays included. They should be stationed in the danger zone where they can get first-hand knowledge of what occurs and the causes leading to it. Congress could not do anything more to assist reforestation and conserve the timber resources of the Douglas fir and white pine regions than to make the small appropriation asked for, which will enable the Weather Bureau to undertake this work.

The Weather Bureau has already done much to assist forest protective agencies. We fully appreciate what they are doing.

The fire hazard on the Pacific coast is growing worse; the potentialities of a catastrophic combination of weather and fire conditions which can bring disaster and ruin unprecedented are here. We are powerless to prevent the atmospheric forces from assembling and venting themselves in all their might, but we may gain a knowledge of their secrets and of the effect of their movements which will enable us to thwart their fury.

LIGHTNING AND FOREST FIRES IN CALIFORNIA.[1]

By S. B. SHOW.

[United States Forest Service, September 17, 1923.]

Thunderstorms with accompanying lightning as a cause of forest fires have become of great importance during, roughly, the past 15 years, or since the national forests in California were put under administration. Foresters therefore are of necessity keenly interested in any contribution to our rather meager knowledge of this subject.

I propose to outline the nature of the problem as it affects the national forests, to point out what we are doing in an effort to solve it, and what seem to be worthwhile lines for future study.

Lightning fires since 1911 have averaged about 440 per year, contributing over 41 per cent of the total fires from all causes. They are by long odds the most important single cause of fires. An analysis of 4,363 fires shows that they occur in extremely concentrated form: 89 per cent of all lightning fires are in June, July, and August; 77 per cent in July and August; and 44 per cent

[1] Presented at meeting of the American Meteorological Society at Los Angeles, Calif., Sept. 19, 1923.

in August alone. The seasonal distribution in the average case parallels the course of mean maximum temperatures, though fires tend to lag behind temperature.

This great seasonal concentration of fires, of course, tends to make suppression difficult, because so many fires occur at one time. The most striking evidence of the difficulty of successfully handling lightning fires is found in the fact that exceptional storms have set in a single day as many as 340 fires. I have classified storms into four general groups, those causing less than 50 fires, those with from 51 to 150 fires, those with from 151 to 250 fires, and those with over 250 fires. In handling fires resulting from storms of the first three classes we have been uniformly successful in holding the size of the average fire to about 35 acres, the figures for each class being 49, 29, and 34. In other words, though many fires result from these generally local storms, our protection organization is equipped to handle the situation.

For the three great general storms which have set over 250 fires, the situation is, however, radically different. Fires from these storms attained an average size of 312 acres, over eight times as great as from storms of the other classes. The largest fires known in northern California resulted from these catastrophes.

In practice, a general electrical storm, such as these, results in what may be regarded as an overload of business. We are not equipped to handle all fires promptly, and must rely on cooperative help, which is not always satisfactory. One of the most important contributions that could be made to organized fire protection in California, and, indeed, throughout the West, would be prediction, even a few hours in advance of the occurrence of these great general storms. We could then do much of the emergency organization work, which must now wait until fires are actually set.

Lightning fires individually are generally not particularly difficult to handle, but in bunches they represent perhaps the most severe test that fire protection forces must meet. During the past decade, on the average, 42 per cent of the entire crop of lightning fires for an entire season have occurred in a single storm, further evidence of the extreme concentration of this form of fire business.

I have spoken briefly of the when and how of lightning fires, and I should now like to speak of the where. We have plotted on a State map the point of origin of each fire for a period of 10 years. Even the most casual study shows that as a matter of recorded experience there are both well-marked lightning centers, and what may, I think, be fairly regarded as lightning zones. It seems evident:

1. That from north to south in the Coast Range, the belt generally decreases in width.
2. The same general trend is apparent in the Sierra Region.
3. In southern California the zones are generally narrower than elsewhere.

In intensity, or number of fires per unit of area, there is a general, though by no means regular, decrease from north to south.

This analysis of the place of occurrence of lightning fires has proved of great value in helping us to most effectively place our men, to organize detection service, etc. On the map there are many blank spots for which no explanation can now be offered. Whether they are purely accidental and will be filled in as more data accumulate is open to question. They may conceivably be out of the principal storm tracks.

This is the lightning fire zone in general. When we analyze the great storms, we find that they cover pretty much the same region. This is not true in detail, but the limit of southerly extension, for example, has been about the same for all three. The national forests to the south are subject to intense storms, but so far have not participated in the most extensive storms. This it seems is a point worthy of cooperative study.

This, then, is the situation in regard to lightning fires in the forests of California. Obviously enough, the greatest contribution to better handling of them would be the ability to predict the occurrence, particularly of the great general storms. It is probably true that these storms are intimately related to the general weather condition and can be predicted, given sufficient study of the problem. The more local convectional storms are also worthy of attention. Undoubtedly lightning storm centers exist, where storms form repeatedly and from which they travel. One such center is certainly the Sierra Valley, another is the region around Mount Shasta.

For three years now the Forest Service has been utilizing its fire lookout men as recorders of the occurrence and movements of storms. Hundreds of observations have been made, and an analysis of this mass of data will doubtless prove of value. If it is found that storms forming in a particular center tend to travel in a given direction, it will be possible to phone ahead of the storm, and thus to make predictions at least a few hours in advance. Similar data have been secured for the past two seasons in Idaho, Montana, Washington, and Oregon, as well as in California, and suggestive leads for further investigation have already been uncovered.

More study, I believe, is needed of the occurrence of lightning storms in relation to general weather conditions. Cooperative study of this phase of the problem should certainly be of value. In general, the securing of field data is probably the most serious difficulty to be overcome in realizing our goal of prediction of lightning storms. It seems to me not beyond the possible that the field men of the Forest Service, particularly our lookouts, may prove to be ideally situated for that purpose.

HOW WEATHER FORECASTING CAN AID IN FOREST FIRE CONTROL.[1]

By HOWARD R. FLINT.

The title subject given above is one so little discussed by those most concerned that one might almost be led to believe that it had been forbidden by a perpetuation of the drastic forest laws of the time of the Norman Conquest or by the merry days of Robin Hood, when an eye or a right forefinger and thumb of the skilled but unhappy archer was the price paid for a minor transgression of the laws of the king's forest. Of course no such taboo has actually existed, but natural conservatism and inertia have ever been about as effective as written legislation in retarding inevitable progress. The result has been a failure on the part of the average forester to make full use of a tool which may be of great use to him.

Ten years ago the average forester would probably have dismissed the subject with the ironic remark that anyone could tell when he was going to have a fire by the absence of rainfall for a fortnight, and that knowing

[1] Presented at meeting of American Meteorological Society, Los Angeles, Calif., Sept. 19, 1923.

in advance when fires would occur would be of little assistance in any event, since they must be met and put out whenever and wherever they occurred.

To-day we find practical foresters, the men who must form the fire-protection organization and build up the fire-suppression machines, consulting daily weather forecasts and, to some extent at least, permitting their judgment to be influenced by what used to be termed the "weather man's guess." These foresters have guessed the weather themselves and are learning by experience that the weather man's "guess" with its present scientific foundation is correct a large and an increasing percentage of the time. They are learning that it is a tool the possibilities of which have only begun to be developed.

Telephone, telegraph, and radio communication, supported by real organization and the spirit of helpful cooperation, make it possible to put the words of the weather forecaster in Chicago or San Francisco in the most remote and isolated ranger headquarters in the northern Rocky Mountains within an hour or two of the time the forecast was formulated. Truly this is magic, and with its aid the matter of fact forester can hope, not to beat Nature at her own game, but to sit in at a game with Nature aided by cards stacked in advance and with better than an even chance winning of a hard contest.

In order that there may be left in the minds of those present no lurking shade of doubt concerning the magnitude and practical importance of the forest-fire problem, it seems advisable to quote a few statistics borrowed from the official records of the northern Rocky Mountain district of the United States Forest Service. This is one of the several important forest regions of the United States. It includes about 40,000,000 acres of land better adapted to the growth of forest trees than any other known crop. It is naturally a region well endowed for the production of wood, but at this time the travels and researches of foresters have revealed no other region in which forest fires are of more frequent occurrence or in which they are more intensive and completely destructive. This condition is due chiefly to the peculiar climatic and vegetative conditions which will be discussed later.

Of the northern Rocky Mountain region 22,000,000 acres are in the national forests. For the past 15 years rather complete and detailed fire researches have been kept for this vast area. There have occurred in that time 18,169 fires of record. They have covered a total area of 4,400,000 acres, some of which, however, has burned over twice, and a little of it three times during the period. More than ten and a half billion feet of merchantable timber has been killed, only a trifling amount of which has been or can be salvaged. The actual money value of the losses has been conservatively estimated at $27,000,000, a staggering sum, and the cost of fighting fires has been over five and a half million dollars. These figures are for national forest lands alone. The losses on private lands in the region have been fully as great, probably greater in proportion to the acreage involved. 88 per cent of all the loss occurred in two seasons, 1910 and 1919, and 53 per cent of the expenditures for fire suppression, was made in these two seasons in a period of about 90 days each. The climate in most of this region is of the Pacific coast type, with the extremes accentuated by the altitude and distance from the ocean. The summers are characterized by extremely low precipitation in June, July, and August, desiccating southwest winds from the semidesert region along the Columbia and Snake Rivers, and very low relative humidities. During July and August storms frequently pass over this region with little or no precipitation, but accompanied by violent electrical discharges. In the season of 1920 an unusually bad one in that respect, 1,281 fires of record were caused by lightning alone. More than 200 of these were set in the national forests of northern Idaho in a single day. The dominant forest growth of the region is made up of coniferous trees—pines, firs, and others—usually in thick stands and having rather dense crowns; foliage that carries a high content of inflammable resins; and bark and wood that burns freely when ignited.

From the standpoint of forest-fire protection the combination forms a most difficult condition and the destructible resources at stake are valued at $140,000,000 in direct tangible values, not to mention other values which can not well be calculated at present.

It is conceivable that a sufficiently large force of men might be placed and held in this region at all times during the summer to cope effectively with any fire situation which might arise. It is apparent that the cost of such an organization would be enormous. It would be useful for that purpose only three months of each year and would necessarily be forced to seek other occupation during the balance of the year. At this time it does not seem possible to justify the cost of an organization of that kind. It would soon absorb the entire value of the resources at stake. The alternative, and the policy which is now in effect, is to maintain a skeleton organization which can readily meet the more common situations and swell this organization in time of fire emergency by the employment of a sufficiently large force of temporary emergency help directed by the specially trained and prepared organization.

It is apparent that the success or failure of this scheme will depend very largely on the prompt and accurate recognition of emergency conditions in time to permit of the marshaling of the emergency forces. It can truthfully be said of forestry, "time is essence thereof." This is true in the infinitesmal and in the large, for "minutes count" in getting action on a fire, and it takes about a century to grow a forest. A single fire, due to a slight error in judgment or the elapse of a few precious minutes in getting action, may undo the good work and sound judgment of a century.

With the aid of the facts outlined above it should be possible to visualize in some degree, or at least to imagine, how really dependable and detailed weather forecasts might be of great value in fire-control work.

To begin with, the forester who has going fires in his district could obtain more effective results and make material savings in cash if he knew in advance with a fair degree of certainty just what the weather held in store for him during the next few hours. Will the wind remain the same or will it swell to a gale? Will the relative humidity drop to 10 per cent to-morrow afternoon, or will it be above 50 per cent? Does the distant cloud presage rain within 24 hours, or will it spread ruin in the shape of a score of new lightning fires over the far-flung dry hills of the district? These are "burning questions." Can the weather forecaster answer in advance any or all of them? It should be an inspiration to know that in a number of cases that have been checked up he has answered them in advance, though seldom in the past has there been the organization or the faith to fully utilize the information.

Lightning is the greatest single cause of forest fires in the region we have been discussing. In these days of rapid transportation and instantaneous communication a few hours' warning of the approach of a violent electrical

storm might be of material value. A single fire often costs thousands of dollars. Is it not possible that a dependable warning could be given? The behavior of radio and telephone instruments during and just before electrical storms and the researches of one or two eminent meteorologists all suggest an affirmative answer.

Again, the forest officer must decide, often in the absence of any unusual number of going fires, whether the time is ripe for the expansion of his forces, to the limit, to a moderate degree, or not at all. Past experience is the only true basis for judgment. Accurate and readily available weather records should supplement, or probably I should say supplant, memory in forming the basis for a judgment which may involve thousands of dollars. Can the meteorologist predict a week or a month in advance the probable general trend of the season?

The researches of Huntington, Douglas, Ricard, and others at least suggest that there are undeveloped possibilities in this line. Casual local observations indicate that there may possibly be a very intimate relation between local summer rainfall and the depth of snow on the higher ranges during the months of May and June.

Briefly, in summarizing the idea set forth in the title of this paper, it may be said that there is at least some warrant for the belief that weather forecasting can aid forest-fire control in at least three different ways, namely—

1. By warning through the usual 36-hour forecasts of an approaching change in the weather which will influence the behavior of possible or going fires.

2. By means of special forecasts which will give warning six or more hours in advance of the occurrence of lightning in any given locality.

3. By warnings through long-range forecasts, based on sunspot or other phenomena, of the approach of abnormal seasons comparable to the seasons of 1889, 1910, and 1919 in the northern Rocky Mountain region.

METEOROLOGICAL FACTORS AND FOREST FIRES.[1]

By J. V. Hofmann.

A gathering of foresters with, and at the invitation of, meteorologists marks the realization of the long-felt need of a close correlation of these natural sciences. This accomplishment leaves behind the cry of the insistent few who were ever urging unity of purpose and cooperation and opens the door to a new era of development that will apply all of the scientific facts to the existing conditions. Meteorological factors and forest development are inseparable in nature, and progress in the establishment of a forestry practice will be measured by the extent that these factors are made inseparable in the study of the sciences. The correlation of the meteorological factors needs no discussion at this meeting, consequently this paper is confined to the individual or collective relation of these factors to the forest conditions.

Although all of the climatic factors are related to the development of the forest, those directly related to the forest fire problems are most important because the control of the fire situation is the greatest question in the conservation of the timber supply. The study of the influence of climatic factors on fire hazard has been continued for two years by the Wind River Experiment Station. These studies have included the effect of all of the meteorological factors on forest fire conditions as well as on the behavior of the fire. Temperature, evaporation, wind and other factors influence the fire hazard, but the relative humidity was found to be the most important factor in the development of a dangerous fire period as well as the most usable factor in actual fire control. * * *

Studies conducted by the Wind River Forest Experiment Station of the effect of relative humidity on forest fires showed that fires did not spread when the relative humidity was above 60 per cent. That they spread very slowly and only in very favorable material when the humidity was between 50 and 60 per cent. When the humidity was between 40 and 50 per cent fires picked up, varying from a few running fires to fires that merely smoked up and did not spread. With a humidity of 30 to 40 per cent fires gained some headway and some rapidly spreading fires occurred. A humidity below 30 per cent caused all fires that were in material that would allow spread at all to gain headway, or spread beyond control. Crown fires occurred when the humidity dropped to 25 per cent or lower. * * *

Unquestionably one of the main causes of our enormous fire losses has been due to the failure to realize how very suddenly forest materials may change from a low degree of inflammability to an extremely high degree of inflammability and convert in a few hours fires which have been smoldering harmlessly for days into raging conflagrations.

A realization of this situation can lead to only one conclusion, that the smoldering fires must be put out immediately while they are small, when they can be handled at small expense and before conditions change. * * *

The season of 1923 has been one of exceptionally low fire hazard in the Pacific Northwest, although on September 12 the deficit in precipitation was nearly 6 inches. Temperature has been high during some periods, but on the whole the relative humidity has been low for only short periods or days, However, a low period of humidity during the first days of September caused the most serious fire period of the year which resulted in many fires that spread rapidly and were beyond the control of the fire fighting forces until September 8 and 9 when the relative humidity remained high again. * * *

The correlation of the meteorological factors and the forest fire hazard that has been discussed in this paper emphasizes the importance of the relative humidity and shows that it is the principal factor that can be used as an index of the fire conditions as well as its direct use in fire control.

With this fact established it is evident that the greatest need in forest fire prevention and control is a knowledge of changes in relative humidity as far in advance as possible.

Recognizing this point, the Wind River Experiment Station is now conducting studies to determine the relation between relative humidity and static electricity. This study has progressed far enough to demonstrate a definite relation, and furthermore that static can be used as a basis for the prediction of changes in humidity.

[1] Excerpts of paper read at meeting of American Meteorological Society at Los Angeles, Calif., September, 1923.

EVAPORATION AS A SIMPLE INDEX TO WEATHER CONDITIONS.

By CARLOS G. BATES, Silviculturist.

[United States Forest Service.]

The principle upon which the use of evaporimeters has been based, in connection with the study of forest fire weather, is very simple. As, in the continental United States, periods of low barometric pressure are commonly periods of rainfall, so also the intervening periods of higher pressure are usually periods in which drying occurs progressively for several days. A measurement of the rate of evaporation probably expresses, in as simple a term as is possible, the rate at which and the extent to which moisture accumulated in the forest litter during wet periods is being or has been dissipated. Every factor which influences the dryness of the forest floor enters into the evaporation rate as measured instrumentally. Even the time and amount of precipitation can be largely ignored, since so long as the moisture of a rain is retained its presence will reduce locally the evaporation rate.

There is an apparent limitation upon the use of the evaporation rate to show the condition of the forest with respect to dryness. Just as the current humidity fails to show the *extent* to which drying may have proceeded, so also, if a constant evaporation rate is maintained for several days, it must be assumed that a certain degree of dryness in the forest has been attained, and very little additional drying is to be expected. To this extent the cumulative evaporation over a long period has no precise statistical value. However, the fact that two succeeding days seldom show the same evaporation rate is an argument in favor of the use of this measure of weather conditions. The evaporation rate increases and decreases by surges, the average period for a complete cycle being about seven days, and, of course, corresponding to the average period between cyclonic storms. The evaporation curve is not symmetrical, the descent from the peak day being more precipitous than the ascent to the peak. It thus becomes apparent that, owing to the cumulative effect of dissipation of the moisture, the rate of evaporation may increase almost up to the time of occurrence of a rain.

The instrument in use in these studies is the so-called "inner cell wick evaporimeter" designed by the present writer and described in the MONTHLY WEATHER REVIEW for May, 1919. This evaporimeter possesses certain practical advantages which, perhaps, make it more valuable than other atmometers in the hands of inexperienced observers. Among the advantages may be mentioned the fact that it functions satisfactorily in freezing weather, when often the greatest fire hazards exist. The greatest difficulty arising in its use has been the impossibility of maintaining its calibration with reference to a standard instrument. The evaporimeter also has not been entirely freed from the influence of splashing rainfall.

Measurements of the loss by evaporation are made in the morning of each day.

During the season of 1922 a number of these inner cell evaporimeters were in use at scattered points in all of the western districts of the Forest Service. The writer has as yet been unable to learn whether any of the users established a correlation between the recorded evaporation rates and the occurrence of fires.

Since May 1, 1923, the inner cell evaporimeters have been in use at five forest headquarters in district 2, in addition to the regular equipment at the Fremont Experiment Station, near Manitou, Colo. Up to the time of preparation of this paper (August 15), the season has been an unusually moist one, so that very few fires have occurred. It is, therefore, almost too early to attempt to show that the evaporation rate is a valuable index of forest fire conditions. Believing that meteorologists will readily concede its possibilities, the object of the present paper must be to point out certain technical features which have developed in the records of 1923, and which may be of interest largely from the meteorological standpoint.

At the outset it was believed that the absolute rate of evaporation might be used as a direct index of the fire hazard. Realizing that the evaporation rate would ordinarily pass through a low phase and a high phase about every seven days, it was believed that the four days during which the rate was below the average would be practically free of fire hazard, while the three days during which the rate was above average would be the period of great danger. After the record for the first such day had been obtained, it might confidently be expected that the two succeeding days would be days of increasing danger, and preparations could be made accordingly.

The few fire records which can be correlated with the records of evaporation during 1923 show that the matter is not so simple as this, however. While the cycles occur with reasonable regularity, they are dissimilar to teach other. Some low-barometric periods bring soaking rains and bring the evaporation curve to the base line, while other low-pressure periods bring only slight rains and the atmosphere quickly becomes dry again. It appears that the fire hazard is only completely relieved when complete saturation of the atmosphere and of the ground occurs. While it is doubtless true that the hazard is lessened by any degree of moisture or rainfall, still, owing to the large number of factors entering into the fire situation, vigilance can not be relaxed unless the relief has been quite complete.

It will, then, be asked, "In what way is the evaporation record superior to the precipitation record?" It is probably superior only in the sense that it leaves little room for judgment as to whether the country has been effectively soaked. For example, a very heavy but localized rain can not sufficiently moisten the atmosphere to hold the evaporation at zero for a 24-hour period. The evaporation record, also, has its value in the period between rains, in showing the *degree of dryness* which exists. The evaporation figure includes the influence not only of relative humidity, but of temperture, sunlight intensity, and wind movement. We have little doubt but that, with further records, a close relation will be found to exist between both the number and intensity of forest fires and the absolute evaporation rate.

The second point to be observed is the dissimilarity of the evaporation curves for the different stations in the same region. During the season of 1923 evaporimeters have been in use at Grand Junction and Manitou, Colo., at Sheridan and Laramie, Wyo., Custer Peak, S. Dak., and Halsey, Nebr. The first two and the last four stations comprise two west-to-east series, in each of which, it was thought, it might be possible to observe the eastward movement of the cyclonic disturbances which, as a whole, have been the greatest influence on the evaporation rate. The results in this respect have

been somewhat disappointing. Neither the 24-hour periods of highest or lowest evaporation at Grand Junction regularly precede the corresponding periods at Fremont, which lies about 170 miles due east. In the Sheridan-Black Hills-Nebraska series the sequence of events appears to be still less regular, although as a general rule the eastward movement can be traced. It appears that both local disturbances and deviations of the cyclonic centers from a regular course inject too many elements of uncertainty to make it practical to forecast the progress of evaporation at any distant point. With the information which is available to the Weather Bureau, it is probable that the rate of evaporation could be forecast, in general terms and for broad regions, as accurately as rainfall and temperatures are now forecast, but it is very doubtful whether this would serve the same purpose as an evaporation record obtained in each locality and subject to local influences.

To close what must be a merely tentative discussion of the evaporation factor as related to forest fire hazards, it may be said:

The records of evaporation obtained at six points during the season of 1923 indicate clearly the character of the variations at any single point and between stations in the same general region. They suggest that the evaporation record comprises a simple means for integrating all of the factors which accompany the periodic changes in barometric pressure, and that this record may have a quantitative value greater than that of any single factor commonly recorded at weather stations—possibly, in relation to fire hazard, greater than any combination of weather elements that might be integrated by computation. It is indicated that evaporation varies so greatly from one point to another near-by point for any single day that to be practically useful to a forest supervisor the evaporation record must be of a local character. It will, possibly, be found later that records obtained in the headquarters towns are not so valuable as those which may be obtained within the forested area.

At least for the present, the absolute evaporation rate can not be considered so important a factor in the fire hazard as the general shape of the evaporation curve. The starting point for all calculations is, apparently, the time when the evaporation rate approaches zero, indicating at least a saturated atmosphere and presumably a well-moistened condition of the forest floor. Because of the importance of this zero point, still further effort should be made to improve the evaporimeter along the line of eliminating all intake of rain water.

TRANSPIRATION BY FOREST TREES.

By ROBERT E. HORTON, Consulting Hydraulic Engineer.

[Voorheesville, N. Y., December 6, 1923.]

HÖHNEL'S EXPERIMENTS.

Aside from scattered data of transpiration from cut branches and meager potometer experiments by Risler, Vogel, Hartig, and Pfaff,[1] few data are available relative to the actual transpiration rate from trees, except the experiments of Franz von Höhnel.[2]

Although published more than 40 years ago, Höhnel's results have not been presented in English otherwise than in brief abstract form. The originals contain numerous misprints, and the results have sometimes been misinterpreted and unjustified conclusions drawn therefrom. It has appeared, therefore, worth while to give these important experiments some further critical study, and present the main results in some detail in English units. Errors and misprints in the originals have been corrected, in so far as possible.

Höhnel's experiments, carried out in connection with the Austrian Forest Service in the years 1878 to 1880, give the transpiration losses and water requirement ratios for a large number of species and varieties of trees. Seedling plants 5 to 6 years old were transplanted to potometers and allowed to stand for three or four weeks to permit the earth to settle. The potometers were 7.8 to 8.2 inches in diameter and 7.5 inches high. Each contained 7.7 to 11 pounds of soil. Conical covers were used to shut out rain, openings being left for the plant stems and for watering through a cork-inserted tube.

In 1878, 44 potometers were used, 24 being exposed in the sun and 20 in the shade. Those in the shade received sunlight from 7 to 9 a. m. and 5 to 7 p. m. For the subsequent years the total number was increased to 79, of which 39 were in the sun, 29 in half shade, and 11 in the shade. The quantity of water transpired was obtained by daily weighings. Meteorological observations were taken three times daily, including temperatures in sheltered, open, and shaded locations, and rainfall and evaporation readings. For each plant the dates of leafing and defoliation were recorded, and at the end of the season the leaf crop was air-dried and weighed and the result recorded. The mean results for 1879 for each variety of tree are given in Table 1. This shows the average transpiration loss in grams from each variety of tree, and also the water requirement ratio expressed in terms of water transpired per unit of dry leaf matter produced.

The water requirement for the year as shown in Table 1 is not always precisely equal to the sum of the water requirement for the summer and winter seasons, as given in the same table. This results from the fact that the experimental data covered the period March 1, 1879, to March 1, 1880, so that in order to obtain the transpiration loss for the period November, 1879, to April 1, 1880, inclusive, the month of March, 1879, was assumed and used to represent the month of March, 1880.

In Table 2 are given the mean water requirements for the same tree in different exposures as determined in 1879. It appears that in general the water requirement ratio for broad-leaved deciduous trees in the sun is about two-thirds that for the same variety in the shade. This result would be expected, since in general any condition unfavorable to plant development increases the water requirement ratio. Actually, the quantity of water transpired from shaded plants averaged considerably more than those in the sun, as shown in Table 3. The difference in the average is mainly due to the excessive transpiration in shade by larch and Scotch pine. Out of 15 kinds of trees for which the comparison is available, 8 transpired more and 7 less in shade than in sun, the excess either way probably depending to some extent on the tree, whether it is to be classed ecologically as sun or shade loving.

[1] Forest influences. *Bull. 7, U. S. D. A.*, 1893, pp. 78-81.

[2] Höhnel, Franz R.: Water requirements of forest trees. (Ger.) *Forsch. Beg. Agrikultur Physik*, 1879, vol. 2, pp. 397-421.

Quantity of transpiration from forest growth. (Ger.) *Mitt. Forst. Veruschwesen Oesterreichs*, 1881, vol. 2, pp. 47, 90, and 287-296.

Water requirement of forest trees with reference to meteorological factors. (Ger.) *Forsch. Beg. Agrikultur Physik*, 1881, vol. 4, pp. 435-445.

The water requirements of forests. (Ger.) *Central Blatt Gesamte Forstwesen*, 1884, vol. 10, pp. 387-409.

TABLE 1.—*Höhnel's experiments on transpiration from trees, March, 1879, to February, 1880.*

Name of tree.	Exposure.	Number of tests.	Dry leaf weight.	Date in leaf.	Date bare.	In leaf.	Total transpiration. Mar. 1 to Mar. 1.	Total transpiration. May to October.	Total transpiration. November to April.	Water requirement ratio = Water transpired / Dry leaf weight. Year.	April.	May.	June.	July.	August.	September.	October.	May to October.	November to April.
			Gm.			*Days.*	*Gm.*	*Gm.*	*Gm.*										
Ash (*Fraxinus excelsior*).	Sun	2	8.79	May 5	Oct. 9	156	7,135.5	7,097	37.9	809	1.0	28.3	219	197.0	233	115	12.2	804	4.55
	Shade	3	3.64	May 3	Oct. 31	181	3,833	3,789	43.4	1,043	4.5	22.4	173.9	301.4	288	196.7	50.6	1,026	16.5
	Halfshade	2	17.15	May 4	Oct. 25	173	18,102	18,047	59.6	1,092	5.9	60.7	228.9	255.5	271	218	58.6	1,083	8.5
	Mean		9.86	...do	Oct. 22	170	9,690	9,643	46.9	981	3.8	37.1	207.3	251.3	264	179.9	40.5	971	9.8
White birch (*Betula alba*).	Sun	2	7.57	Apr. 8	Oct. 1	160	4,721	4,624	97.8	632	10.7	103.0	134.3	157.0	190.9	29.6	2.1	616.6	15.2
	Halfshade	2	19.10	Apr. 9	Oct. 27	201	19,670	19,316	355.0	1,066	18.7	77.9	145.6	244.3	327.9	174.8	73.5	1,044.2	21.8
	Mean		13.33	Apr. 8	Oct. 14	180	12,195	11,969	226.4	849	14.7	90.4	139.9	200.6	259.4	102.2	37.8	830.4	18.5
Beech (*Fagus sylvatica*)	Sun	7	5.98	May 6	Oct. 31	178	4,328	4,253	74.6	816	10.8	129.5	163.6	191.7	206.5	139.2	52.3	793.9	22.3
	Shade	5	6.51	May 5	Nov. 1	179	5,013	4,918	94.7	968	7.7	55.4	189.6	240.0	255.4	163.7	42.5	943.4	25.6
	Halfshade	1	6.77	Apr. 30	Nov. 26	210	9,111	9,020	90.3	1,346	2.7	14.6	304.3	348.4	341.7	145.1	46.6	1,332.5	13.3
	Mean		6.43	May 3	Nov. 9	189	6,151	6,064	86.5	1,043	7.1	66.5	219.2	260.0	267.9	149.3	47.1	1,023.3	20.4
Hornbeam or ironwood (*Carpinus betulus*).	Sun	2	6.52	Apr. 15	Oct. 14	182	5,045	4,866	178.8	794	22.4	43.7	154.2	210.6	193.5	129.9	32.7	764.8	29.5
	Shade	2	3.57	May 1	Oct. 22	174	2,763	2,653	109.5	776	7.8	38.1	123.1	197.5	195.2	146.6	30.5	732.2	43.6
	Halfshade	2	4.71	May 17	Oct. 25	160	4,154	4,066	87.6	792	4.9	8.7	69.0	198.9	302.9	180.2	122.6	767.1	24.5
	Mean		4.93	May 1	Oct. 20	172	3,987	3,862	125.3	787	11.7	30.2	115.4	202.3	230.5	152.2	61.9	754.7	32.5
Field elm (*Ulmus campestris*).	Sun	2	12.88	Apr. 16	Oct. 15	182	8,029	7,844	184.8	617	11.1	43.1	128.5	140.9	173.2	102.3	14.1	601.8	15.4
	Shade	3	3.37	May 5	Oct. 23	200	2,663	2,545	118.1	860	30.1	68.4	181.2	194.7	205.9	139.9	29.2	819.9	40.4
	Mean		8.12	May 10	Oct. 19	191	5,346	5,195	151.4	738	21.1	55.7	154.8	167.8	189.5	121.6	21.6	710.8	27.9
"Stiel" oak (*Quercus pedunculus*).	Sun	1	6.63	May 3	Oct. 15	165	3,012	2,913	99.0	454	4.5	60.5	103.3	112.3	92.1	60.8	1.0	439.4	14.9
"Trauben" oak (*Quercus sessilifolia*).	Sun	1	9.55	May 7	Oct. 23	169	4,896	4,698	197.5	513	6.3	22.4	89.0	82.6	140.5	122.9	34.6	491.9	20.7
	Shade	1	2.71	Apr. 28	Oct. 29	184	2,891	2,811	80.2	1,067	11.6	30.4	172.9	225.9	271.6	242.2	89.9	1,032.8	33.8
	Mean		6.13	May 2	Oct. 26	176	3,893	3,754	138.8	790	8.9	26.4	130.9	154.2	206.0	182.5	62.2	762.3	27.2
"Zerr" oak (*Quercus cerris*).	Sun	4	11.18	May 5	Oct. 24	172	4,557	4,435	122.4	411	2.2	11.0	87.6	86.4	132.8	65.6	16.5	400.2	10.9
	Halfshade	3	17.13	May 12	Nov. 5	177	14,384	14,173	210.9	927	2.3	36.3	120.8	208.2	295.1	174.1	59.5	894.3	32.7
	Mean		14.15	May 9	Oct. 30	174	9,470	9,304	166.6	669	2.25	23.6	104.2	147.3	213.9	119.8	38.0	647.2	21.8
Black alder (*Alnus glutinosa*).	Sun	1	11.8	Apr. 9	Oct. 23	197	4,941	4,612	329.4	419	22.1	45.6	71.7	115.0	74.2	61.1	23.3	390.8	27.9
	Shade	1	4.8	...do	Oct. 29	206	6,058	5,538	519.9	1,262	95.1	195.1	253.9	339.2	175.1	140.6	49.9	1,153.7	108.3
	Mean		8.3	...do	Oct. 26	201	5,499	5,075	424.6	840	58.6	120.3	162.8	227.1	124.6	100.8	36.6	772.2	68.1
Gray alder (*Alnus incana*).	Sun	3	18.27	Apr. 10	Oct. 18	191	9,361	9,064	296.7	537	12.3	41.5	149.4	108.5	141.6	61.0	18.2	520.3	16.8
	Shade	3	4.64	Apr. 15	Oct. 12	169	3,850	3,672	178.4	819	28.3	40.3	150.1	218.3	187.8	137.4	44.5	781.1	37.4
	Mean		11.45	Apr. 12	Oct. 15	180	6,605	6,368	237.5	678	20.3	40.9	149.7	163.4	164.7	99.2	31.3	650.7	27.1
Sycamore maple (*Acer platinoides*).	Sun	2	14.55	Apr. 8	Oct. 12	186	5,410	5,325	85.2	368	4.0	31.1	85.6	95.4	85.9	60.2	3.9	362.3	5.9
	Shade	2	4.38	Apr. 6	Oct. 29	205	2,945	2,887	58.1	672	8.6	71.7	147.0	140.8	166.3	110.4	22.1	658.4	13.2
	Mean		9.46	Apr. 7	Oct. 20	195	4,178	4,106	71.6	520	6.3	51.4	116.3	118.1	126.1	85.3	13.0	510.3	9.5
Mountain maple (*Acer pseudoplat*).	Sun	3	9.76	Apr. 19	Oct. 1	165	5.435	5,315	119.9	549	6.9	47.3	161.1	126.9	161.9	38.2	3.9	537.0	12.6
	Shade	1	5.98	Apr. 10	Oct. 15	188	3,722	3,575	147.0	622	20.3	42.0	101.2	165.8	161.3	111.0	16.4	597.7	24.6
	Half shade	2	22.15	May 10	Oct. 16	159	16,214	16,111	102.7	734	0.9	55.3	130.6	162.4	239.8	115.0	25.9	729.0	4.6
	Mean		12.63	Apr. 24	Oct. 11	171	8,457	8,334	123.2	635	9.4	48.2	130.9	151.7	187.6	88.1	15.4	621.2	13.9
Field maple (*Acer campestre*).	Shade	1	2.40	Apr. 10	Oct. 29	202	3,074	2,956	118.3	1,281	41.7	87.6	234.4	272.2	306.9	242.5	76.7	1,232.0	49.3
Linden (*Tilia grandifolia*).	Sun	1	7.40	Apr. 25	Sept. 29	157	7,167	7,099	66.5	968	3.6	57.5	309.9	268.8	283.1	38.6	1.4	959.3	8.9
	Shade	1	3.32	Apr. 9	Oct. 29	203	3,677	3,525	151.6	1,107	35.9	65.7	209.7	243.5	310.6	170.3	62.0	1,061.9	45.5
	Mean		5.36	Apr. 17	Oct. 13	180	5,422	5,312	109.1	1,038	19.7	61.6	259.8	256.1	296.8	104.4	31.7	1,010.6	27.2
Aspen (*Populus tremula*).	Sun	1	5.52	Apr. 20	Oct. 15	178	4,820	4,679	141.3	873	21.6	84.4	165.3	185.3	246.1	142.3	24.2	847.5	25.6
Service berry or beam tree (*Sorbus tormin*).	Shade	1	1.56	...do	Oct. 29	182	2,727	2,635	91.9	1,748	31.8	90.6	251.4	357.4	555.4	345.4	88.9	1,689.1	58.9
Larch (*Larix europea*).	Sun	1	0.74	Apr. 15	Nov. 30	229	948	906	41.7	1,281	28.2	71.6	108.2	160.9	217.9	446.6	219.5	1,224.8	56.3
	Half shade	1	15.20	Apr. 7	...do	237	15,929	15,422	506.9	1,048	29.7	60.0	144.1	244.6	331.1	169.0	65.6	1,014.6	33.3
			7.97	Apr. 11	...do	233	8,438	8,164	274.3	1,165	28.9	65.8	126.1	202.7	274.5	307.8	142.5	1,119.7	44.8
Spruce (*Abies excelsa*).	Sun	3	27.0			365	6,346	5,113	1,232.2	251	14.2	21.2	60.6	52.5	43.9	29.8	15.1	203.2	47.6
	Half shade	2	38.3	May 19		365	10,503	9,235	1,268.6	303	7.2	27.4	46.8	63.5	84.3	39.1	11.2	267.4	35.2
	Shade	3	28.85			365	4,691	3,938	752.6	171	5.2	16.0	26.4	58.2	32.5	22.4	25.7	144.5	26.3
	Mean		31.38			365	7,180	6,096	1,084.3	242	8.9	21.5	44.6	58.1	53.6	30.4	17.3	205.0	36.5
Fir (*Abies pectinata*).	Sun	3	36.55			365		3,044			2.7	8.1	12.3	17.2	15.4	9.4	4.3	67.8	
	Shade	1	29.0			365	2,793	2,566	227.0	96	2.07	4.9	13.5	19.5	24.5	18.6	7.4	88.5	7.8
	Mean		32.77			365		2,805			1.38	6.5	12.9	18.3	19.9	14.0	5.8	78.1	
Scotch white pine (*Pinus silvestris*).	Sun	3	23.05			365	2,699	2,334	365.0	116	4.2	9.8	18.6	16.1	16.5	17.6	8.8	100.9	15.4
	Half shade	1	193.0			365	20,191	19,002	1189	105	1.1	2.07	13.2	27.7	28.6	21.0	5.9	98.5	6.2
	Mean		108.02			365	11,445	10,668	777	110	2.6	5.9	15.9	21.9	22.5	19.3	7.3	99.7	10.8
Black Austrian pine (*Pinus larico*).	Sun	2	26 1			365	2,689	2,245	443.5	101	1.8	4.6	14.5	19.6	22.7	15.2	7.7	84.0	16.9
	Shade	2	15.85			365	2,144	1,819	325.4	145	5.3	15.4	28.7	25.6	28.3	18.0	7.2	123.4	21.8
	Mean		20.97			365	2,416	2,032	384.5	123	3.5	10.0	21.6	22.6	25.5	16.6	7.4	103.7	19.3

TABLE 2.—*Comparative water requirement ratios (transpiration per unit dry-leaf matter) for trees grown in different exposures—Höhnel's experiments of 1879.*

Tree.	All tests.		In shade.		Half shade.		In sun.	
	Number.	R_w.	Number.	R_w.	Number.	R_w.	Number.	R_w.
Ash	7	983	3	1,031	2	1,089	2	805
Beech	16	860	5	951	4	841	7	805
Birch	4	845	.....	.....	2	1,062	2	627
Hornbeam	6	759	2	740	2	750	2	787
Elm	5	755	3	840	.....	.....	2	613
Gray alder	6	671	3	809	.....	.....	3	532
Oak	3	662	1	1,044	.....	.....	2	471
Maple	6	618	1	618	2	730	3	544
Oak	7	614	.....	.....	3	896	4	402
Sugar maple	4	517	2	668	.....	.....	2	366
"Common" oak	1	444	.....	.....	.....	.....	1	444
Oak	2	771	1	1,044	.....	.....	1	498
Black alder	2	831	1	1,249	.....	.....	1	412
Field maple	1	1,273	1	1,273	.....	.....	.....	.....
Linden	2	1,030	1	1,098	.....	.....	1	963
Aspen	1	869	.....	.....	.....	.....	1	869
Beam	1	1,721	1	1,721	.....	.....	.....	.....
Broad leaf woods	74	789	25	944	15	888	34	627
Spruce	8	206	3	150	2	275	3	217
Scotch pine	4	104	.....	.....	1	100	3	105
Austrian pine	6	100	2	129	2	85	2	86
Fir	4	76	1	90	.....	.....	3	70
Evergreen needle-leaved	22	135	6	133	5	164	11	123
Larch	2	1,149	.....	.....	1	1,044	1	1,253

TABLE 3.—*Actual transpiration losses, in grams, from seedling trees in different exposures, May–October, 1879. (Höhnel's data, 5½-year seedlings).*

	In sun.		Shade.		Half shade.		Mean.[1]	
	Number.	Grams.	Number.	Grams.	Number.	Grams.	Number.	Grams.
Ash	2	7,097	3	3,789	2	18,047	7	9,643
Birch	2	4,624	.....	.....	2	19,316	4	11,969
Beech	7	4,253	5	4,918	1	9,020	13	6,064
Ironwood	2	4,866	2	2,653	2	4,066	6	3,862
Elm	2	7,844	3	2,545	.....	.....	4	5,195
Oak [2]	1	4,698	1	2,811	.....	.....	2	3,754
Do [3]	4	4,435	.....	.....	3	14,173	7	9,304
Black alder	1	4,612	1	5,538	.....	.....	2	5,075
Gray alder	3	9,064	3	3,672	.....	.....	6	6,368
Maple [4]	2	5,325	2	2,827	.....	.....	4	4,106
Do [5]	3	5,315	1	3,575	2	16,111	6	8,334
Linden	1	7,099	1	3,525	.....	.....	2	5,312
Larch	1	906	1	15,422	.....	.....	2	8,164
Spruce	3	5,113	2	9,235	3	3,938	8	6,096
Fir	3	3,044	1	2,566	.....	.....	4	2,805
Scotch pine	3	2,334	1	19,002	.....	.....	4	10,666
Austrian pine	2	2,245	2	1,819	.....	.....	4	2,032
Means	.....	4,600	.....	5,590	.....	.....	.....	.....

[1] Mean of the means for sun, shade, and half shade.
[2] "Trauben."
[3] "Zerr" oak.
[4] Sycamore maple.
[5] Mountain maple.

The mean values of the water requirement ratios obtained from experiments in each of the different years are shown in Table 4. With reference to this table it should be noted that the values given are averages for all plants of a given kind, regardless of exposure. With reference to the results given in Table 4 it will be noticed that there was in general progressive increase in the water requirement ratio from year to year. The results for the years 1879 and 1880 are much more concordant with each other than either is with the results for 1878, which latter are very small. Zon [3] (p. 234) states:

> The difference in the amount of transpiration in different years is explained by the fact that the years 1879 and 1880 had more rain and therefore more water penetrated the soil.

[3] Zon, Raphael: Forests and water. *National Waterways Comm. Final Report.* Washington, 1912, Appendix V, pp. 205–273.

Actually, this would more probably cause a decrease of the water requirement ratio rather than an increase such as actually occurred. The relative amounts of dry leaf production in the two years are shown in Table 5. In view of the well-known fact that the use of potometers of inadequate size increases the apparent water requirement ratio, it seems probable that the larger values of 1879 and 1880 may have been in part due to this cause. However, Fernow[1] (p. 78), discussing these experiments, suggests that the increased water requirement after 1878 was due to the later experimental seasons being more favorable to transpiration. Unfortunately, complete meteorological data accompanying the experiments are not published by Höhnel. Such data as are available are included in Table 6. It appears that the air temperatures were not materially different in 1879 from those in 1878, although in general they were slightly higher. The manner in which the evaporation was measured is uncertain. A Piche evaporometer is mentioned, but the published results (see Table 6) are very much less than would naturally be obtained from either this instrument or from an ordinary open water atmometer. From known data and the published air temperatures, the approximate evaporative capacity has been computed for the seasons 1878 and 1879, as shown in Table 7. The amounts for the growing seasons in the two years are practically identical. The number of plants was approximately doubled in 1879. All the available data indicate that larger transpiration ratios for the later years were probably caused, in part at least, by inadequate size of potometers for the larger plants.

Referring to Table 4, the lower water requirement ratio for 1878 is in part due to the fact that the experiments do not include the month of May for that year. The data for 1879 show that the total water requirement for the months of May to October, inclusive, is 10 to 15 per cent greater than that for June and November. This results from the fact that the transpiration loss drops off very rapidly after the 1st of October, and is very slight for November. The difference between the transpiration for November, which is included, and May, which is excluded in the result for 1878, amounts to 10 or 15 per cent of the total. Even with this correction, there is still a marked progressive increase in the water requirement ratios between 1878 and 1880.

TABLE 4.—*Average water requirement ratios for trees, Höhnel's experiments, growing season.*

Tree.	1878 [1 2]	1879 [1 3]	1880 [1 3]	Mean.[1]	1879, Weighted mean.[4]
1	2	3	4	5	6
Birch	680	845	918	814	830
Ash	567	983	1,018	856	971
Hornbeam	563	759	872	731	755
Beech	472	860	914	749	1,023
Sycamore maple	463	517	612	531	510
Mountain maple	436	618	704	586	621
Elm	407	755	823	662	711
Oak "Stiel" / Oak "Trauben"	283	622	692	532	600
Oak "Zerr"	253	614	492	453	647
Spruce	58.5	206	140	134.8	205
Scotch pine	58.0	104	121	94.3	99.7
Fir	44.0	72.5	94	70.2	78.1
Austrian pine	32.1	100.0	70	67.4	103.7

[1] Direct averages regardless of relative numbers of sun and shade plants.
[2] June to November, inclusive.
[3] April to October, inclusive.
[4] Sun, shade and half shade plants each given equal weight. These data are for May to October, inclusive.

TABLE 5.—*Comparison of Höhnel's transpiration data for 1878 and 1879.*

Tree.	Dry leaves.		Total transpiration. June to November.	Total transpiration. May to October.	Water requirement ratio. June to November.	Water requirement ratio. May to October.
	1878	1879	1878	1879	1878	1879
	Grams.	*Grams.*	*Grams.*	*Grams.*		
Ash	6.51	9.86	3,508	9,643	567	971
Birch	4.05	13.33	2,569	11,964	690	830
Beech	4.21	6.43	1,430	6,064	444	1,023
Ironwood	3.32	4.93	2,064	3,862	562	754
Elm	5.66	8.12	2,560	5,195	442	711
Oak	7.30	8.97	1,760	5,324	275	616
Fir	49.68	32.77	2,378	2,805	5,030	78.1
Pine	31.5	108.02	1,251	10,668	4,504	99.7
Maple	5.28	8.16	1,698	5,236	345	787
Linden	3.65	5.36	2,284	5,312	615	1,011
Aspen	4.70	7.97	3,494	8,164	743	1,120

TABLE 6.—*Meteorological data accompanying Höhnel's experiments on transpiration by trees.*

Month.	Air temperature. Open.	Air temperature. Shade.	Evaporation, free water surface. Sun.	Evaporation, free water surface. Shade.	Precipitation.
1878.	*° F.*	*° F.*	*Inches.*	*Inches.*	*Inches.*
June [1]	64.9	62.8	1.44	1.07	....
July	63.3	62.4	1.45	1.38	....
August	63.7	63.5	.86	1.01	....
September	59.2	59.3	.66	.76	....
October [2]	49.1	50.9	.39	.63	....
1879.					
April	....	47.8	....	....	3.91
May	....	53.1	1.17	....	6.06
June	....	64.9	1.86	....	4.31
July	....	62.6	1.77	....	4.10
August	....	65.1	1.81	....	1.57
September	....	59.4	1.40	....	1.33
October	....	46.0	.76	....	2.09
May-October	....	....	....	....	19.46

[1] June 14-30. [2] Oct. 1-10.

TABLE 7.—*Calculated evaporation capacity for temperature of air in shade, with 70 per cent humidity, and wind 5 miles per hour.*

Month.	Θ_s.	E_e.
1878.		
June	62.8	6.30
July	62.4	6.20
August	63.5	6.50
September	59.3	5.60
October	50.9	4.10
		28.70
1879.		
April	47.8	3.60
May	53.1	4.50
June	64.9	6.80
July	62.6	6.20
August	65.1	6.80
September	59.4	5.60
October	46.0	3.40
		28.80
April-October	....	36.90
May-October	....	33.30

Referring to Table 5 it will be noted that the dry leaf production in 1879 was in general much greater than in 1878, the increase averaging 50 per cent at least. This would indicate that the seedlings suffered severely in transplanting, and did not make any material growth in the first year. The actual amounts of transpiration in 1879, allowing for differences in the months covered in the two seasons, were as a rule at least double those in 1878. This results in part from the larger extent of leaf surface and in part from the higher water requirement ratios. As already pointed out, the meteorological data while incomplete, do not, as far as they go, afford a sufficient basis for explanation of these differences. An hypothesis which is consistent with the facts is that in 1878 the trees suffered a severe set-back from transplanting but had sufficient root space in the potometers so that while the leaf production and actual transpiration are both low, the water requirement also is low. In the subsequent years, growth tended to normality, but the crowding of the root systems by the small size of the potometers produced a progressive increase in the water requirement. From these considerations the results for 1878 are of doubtful utility. Those for 1880 probably give too high water requirement ratios. Those for 1879 are the most nearly normal.

The results for 1879 do not in general differ materially from the mean of the three years; however, since the number of potometers in use in 1879 and 1880 was double that in 1878, the values for 1879 represent a better balanced average for sun, shade, and half shade conditions than those of 1878. Since it is not advisable to combine the years 1879 and 1880, on account of apparently excessive transpiration ratios for the latter year, the best available interpretation of these data for practical uses appears to be the utilization of the weighted mean results for 1879, as shown in column 6 of Table 4.

BASIS OF APPLICATION OF HÖHNEL'S RESULTS.

Höhnel's published results have been available for 40 years but have received little application owing to the lack of certain data. In conjunction with the original results, the dimensions of the experimental trees are not given, but only the age and the weight of dry leaf matter produced. The final results, being expressed in terms of water requirement ratio per unit of dry leaf matter produced, apparently require for their practical application to full-grown trees the determination, directly or indirectly, of the average annual weight of dry leaf matter. Data regarding the weight of leaves produced by different kinds of trees are very limited. Höhnel estimated a 50 to 60 year old beech to have 35,000 leaves; a full-grown birch, standing in the open, 200,000 leaves. The transpiration from beech was estimated as 22 pounds, daily, which for 500 trees per acre, would be equivalent to 7.28 inches depth on ground area per season.

Höhnel estimated that a fully stocked beech stand, 115 years old, consumed from 1,560 to 2,140 tons of water per acre, or a depth of 13.86 inches. Numerous estimates of water consumption by forests have been published purporting to be based on Höhnel's data. In general such estimates ultimately rest on measurements made from a single full-grown tree of a single variety, and represent some assumed average forest stand, and are not applicable to other conditions.

In view of the great importance of the problem of forest water consumption and of the extent and relative completeness of Höhnel's data, it has seemed desirable to find, if possible, some rational basis of application of these results. For this purpose leaf crop determinations were made by the author on well-developed trees of most of the kinds experimented on by Höhnel. If, then, it may be fairly assumed that the weight of the leaf crop for a given size of tree depends on the diameter and height of tree, it becomes possible to apply Höhnel's data to the calculation of transpiration, using data ordinarily obtainable, namely, the diameter, height, and number of trees of each species on a given area.

LEAFAGE DETERMINATIONS FOR VARIOUS TREES.

The grounds adjoining the author's laboratory includes wide variety of topographical and ecological conditions, ranging from deep ravines to steep ridges with lower river bottoms and marshy tracts. Trees of most of the species and similar varieties to those experimented on by Höhnel are indigenous to this area, and leaf crop determinations thereon were made in 1921.

The method pursued consisted in cutting down mature trees of each species or variety, with the exception of beech, for which the only specimen available was retained for ornamental purposes. In the case of trees cut down, the two butt diameters, total height of tree and height and two diameters of crown were measured, and the number of leaves determined. In the case of broad-leaved trees this was accomplished by direct counting; the branches were trimmed and cut to a convenient size for the purpose and mixed samples of typical leaves were secured in all cases. The samples were placed in trays or, in case branches were used, on wire screens, and were dried in a loft at air temperature for eight weeks. For deciduous trees two leaf samples were then selected, containing usually about 100 leaves each. These were accurately weighed on a sensitive torsion balance. In the case of hemlock the diameters of all branches were measured and recorded. Branches of several diameters were selected and preserved as samples; leaves were stripped from each branch and weighed separately. A relation curve between diameter of branch and dry leaf weight was then derived and applied to all branches, and the total leaf weight was determined indirectly. In the case of pines the number of leaf fronds on each tree was counted and samples, each containing a given number of fronds, were dried and afterwards weighed. For the beech, all branch diameters were measured, leaf counts were made from several sample branches of different diameters cut off for the purpose. A relation curve was then established between branch diameter and number of leaves, from which the total number of leaves on the tree was estimated and the total leaf weight determined by application of the results obtained from weighing dried leaf samples.

The beech tree was in a hedge bordering a pond but standing on upland 10 feet above the pond level. The elm, hornbeam, and basswood trees were from the margin of a thicket, bordering a swampy area, but the trees themselves standing on upland several feet above the swamp. The other tree samples were all from the interior of an extensive forest. Care was used to select sound trees where possible, and those which were developed normally, and which were neither overexposed to the light nor overcrowded. The samples were taken early in September, 1921, before frost and before defoliation began, but at a time when the leaf crop was mature. The ages of the trees were determined by counting the growth rings. In addition to the larger trees described, samples of thrifty young trees, sometimes two or three of each variety, were cut and measured, the leaves counted, and the leaf weight estimated from the unit weights per 100 dry leaves determined from experiments on the larger trees. The data for the two classes of trees are given in Tables 8 and 9.

The results given in Table 8 are for trees averaging about 6 inches diameter by 40 feet height and generally about 50 years of age. Table 9 contains similar results for much younger trees, 5 to 10 years of age. Column 9 of each table shows the air-dry weight of leaves per unit of diameter-height of the tree. Column 15 of each table gives the ratio of the air-dry weight of leaves to a factor determined by multiplying the circumference by the height of the tree crown. This factor is approximately proportional to the surface area of the crown. These ratios for the smaller trees are, however, uncertain, owing to the extremely irregular contours of crowns of very young trees. Comparing the ratios of leaf weight to the crown area factor, column 15, for the two tables, it appears that in general this ratio is larger for the 50-year-old than for the young trees. This would naturally be expected from the following considerations. The volume inclosed by the leaf mass of a typical tree may be looked upon as a solid of revolution, generated about the axis of the tree trunk, but with a hollow core. The whole volume inclosing the leaves is shaped something like an ordinary glass telephone insulator in the case of typical hardwoods, like the maple, but ranges in form for other trees from a hollow cone for hemlocks to a hemisphere for oaks. The leaf mass if of varying thickness in different kinds of trees but in trees of a given species the thickness of the leaf mass increases with age of the tree up to a certain limit, so that for very young trees the thickness of the leaf mass is less and the weight of leaves per unit of surface area of the crown is less than for older trees.

TABLE 8.—*Leaf production, larger trees.*

Kind of tree.	Diameter.	Age.	Height.	Diameter× height of tree 2×4.	Number of leaves, total.	Weight per 100 leaves.	Total air-dry weight of leaves.	Ratio 8/5	Height to crown.	Height of crown.	Diameter of crown.	Circumference of crown.	Circumference× height of crown 11×13.	Ratio 8/14
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Inches.	*Years.*	*Feet.*			*Ounces.*	*Ounces.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*		
Hickory	8.06	54	42	338	14,220	1.165	165.66	0.490	32	10	17	53.41	534	0.310
White pine	8.06	47	42	338	[1] 5,940	4.45	264.33	.782	32	10	17	53.41	534	.495
Black ash	4.87	52	40	195	16,270	.437	71.10	.364	31	9	12	37.70	339	.210
Poplar	6.12	45	40	245	2,771	1.764	48.88	.199	30	10	12	37.70	377	.129
Soft maple	3.75	32	33	125	4,061	1.05	42.64	.341	8	25	13	40.84	1,020	.0418
Black oak	6.25	48	41	256	8,482	2.302	195.25	.762	24	17	14.5	45.60	775	.252
White oak	6.06	48	41	248	9,663	1.358	131.22	.530	13	27	11.5	36.13	975	.135
Chestnut	6.87	55	49.6	341	2,687	1.766	47.45	.139	36	13.6	9.5	29.84	541	.088
Ironwood	3.12	42	31.5	97	9,476	.40	37.90	.391	11.5	20	12	37.70	754	.050
Hemlock	8.12	95	35.1	285			342.0	1.200	8	27.1	13.5	42.41	1,149	.298
Yellow pine	5.87	45	43.6	256			189.5	.740	29.3	14.3	7	21.99	314	.603
Water beech	2.25	18	18	40.5	2,369	.470	11.3	.275	3	15	12.5	39.27	590	.0189
Basswood	8.25	50	45.2	373	16,128	1.195	192.73	.516	18	27.2	28	87.96	2,394	.0806
White birch	3.50	22	26.5	89	2,611	1.006	26.27	.295	7	19.5	10.5	32.99	650	.0404
Black alder	3.94	19	21.7	85.5	2,688	.965	25.94	.303	1	20.7	18	56.55	1,172	.0222
Elm	4.37	15	25	109	14,366	.750	107.75	.990	6	19	10	31.42	597	.180
Beech	9.75		38	370	29,100	.510	148.41	.401	6	32	30	94.25	3,014	.0493

[1] Fronds.

TABLE 9.—*Leaf production, young trees.*

Kind of tree.	Diameter.	Age.	Height.	Diameter× height of tree, 2×4.	Number of leaves, total.	Weight per 100 leaves.[1]	Total air-dry weight of leaves.	Ratio[2] 8/5	Height to crown.	Height of crown.	Diameter of crown.	Circumference of crown.	Circumference× height of crown, 11×13.	Ratio 8/14.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Inches.	*Years.*	*Feet.*			*Ounces.*	*Ounces.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*		
White oak	0.48	8	5.0	2.4	194	1.358	2.63	1.096	1.83	3.17	1.67	5.24	16.61	0.159
Soft maple	.47	7	6.75	3.17	240	1.05	2.52	.795	2.00	4.75	2.42	7.60	36.10	.070
Do	.21		2.60	.55	25	1.05	.26	.473	.60	2.00	1.25	3.93	7.86	.033
Do	.18	....	2.50	.45	27	1.05	.28	.622	.80	1.7	.75	2.36	4.01	.069
Black oak	.59	8	5.5	3.24	203	2.302	4.67	1.441	2.00	3.5	4.33	13.6	47.60	.098
Ironwood	.63	11	6.0	3.78	430	.40	1.72	.456	1.50	4.5	3.38	10.6	47.7	.036
Basswood	.53	9	5.67	3.01	282	1.195	3.37	1.120	1.5	4.17	2.25	7.06	29.4	.115
Do	.22	5	2.33	.51	38	1.195	.45	.882	.25	2.08	.58	1.83	3.81	.119
Hickory	.51	9	5.0	2.55	323	1.165	3.77	1.480	.67	4.33	1.42	4.46	19.31	.175
Chestnut	.48	10	6.16	2.96	140	1.766	2.47	.835	1.08	5.08	2.50	7.85	39.87	.0619
Black ash	.48	8	6.33	3.04	157	.437	.69	.227	2.75	3.58	2.17	6.82	24.41	.0283
Black alder	.71	11	8.42	5.97	881	.965	8.50	1.425	1.84	6.58	4.08	12.8	84.22	.101
Elm	.52	5	3.5	1.82	209	.75	1.53	.840	1.58	1.92	3.38	10.6	20.35	.075
Beech	.64	11	5.25	3.36	302	.51	1.54	.458	1.33	3.92	1.92	6.03	23.63	.0653
Hemlock	1.05	13	5.0	5.25			[3] 10.97	2.09	.25	....	4.33	13.6	....	
White pine	2.13	18	13.75	29.3	[4] 490	1.85	9.07	.312	8.5	5.25	3.50	11.0	57.75	.157
Do	.55	8	2.67	1.47	[4] 97		[3] 1.02	.694	.17	2.50	1.75	5.5	13.75	.0739
Do	.36	3 (?)	1.92	.69	[4] 41	....	[3] .29	.409	.17	1.75	1.08	3.39	5.36	.0541

[1] From determinations on samples from full-grown trees, air dry.
[2] Diameter in inches×height in feet divided by leaf weight per 100 in ounces avoirdupois.
[3] Actual weight.
[4] Fronds.

DIAMETER-HEIGHT RELATIONS OF TREES.

The usual data available as a basis for determining the transpiration loss from a forest are the numbers of trees of different species and diameters. In what follows it is assumed that these data are available. If, as is sometimes the case, only the age of the forest is known, then it is assumed that the diameters are taken as the normal diameters for trees of a given age. Of course, the heights of the trees are also sometimes given in forest cruisers' tables, but in rapid forest inspection for hydrological work the diameters are more readily estimated or measured than the heights.

For the same species of trees grown in different localities the normal heights and diameters at a given age vary considerably. This is illustrated for hemlock by Table 10. It will be noted, however, that for tress of the same diameter the heights are approximately the same, although the ages at which trees reach a given diameter in different localities are often quite different. Similar data for lodgepole and western yellow pine are given in Table 11. Even for trees of the same species but different varieties the relation between diameter and height at a given age is fairly uniform, as illustrated for hickories by Table 12.

All that has been given with reference to age, diameter, and height relations for trees refers exclusively to forest-grown trees. Isolated trees in the open as a rule have less height, greater crown width, and a smaller ratio of height to diameter. It is not to be expected that the diameter-height relations will apply with accuracy to individual trees; however, in estimating the transpiration from any considerable area of forest, all that is required is the average or statistical relation. With reference to individual trees, the variations in height for a given diameter are usually maintained within well-defined limits, more nearly constant as the trees grow older, but the maximum and minimum heights for a given diameter are usually within 25 per cent of the average for the same diameters, as shown in Table 13.

TABLE 10.—*Age, height, and diameter relations for hemlock.*[1]

Age, years.	Leelanau County, Mich.		West Virginia slope type.		Tennessee slope type.		North Carolina cone type.		Otsego County, N. Y.	
	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
	Ins.	*Feet.*	*Ins.*	*Feet.*	*Ins.*	*Feet.*	*Ins.*	*Feet.*	*Ins.*	*Feet.*
20	0.7	8	0.4	......	0.2	......	......	......	0.4	7
30	1.3	12	.9	......	.9	9	1.1	15	.9	10
40	2.1	16	1.3	11	1.9	16	2.2	23	1.4	13
50	2.9	20	1.9	14	3.0	23	3.4	30	1.9	16
60	3.8	25	2.4	17	4.1	30	4.7	36	2.5	20
70	4.7	30	2.9	20	5.3	37	6.2	42	3.3	24
80	5.7	35	3.6	24	6.7	44	7.6	47	4.0	28
90	6.7	40	4.2	27	8.0	51	9.1	53	4.7	32
100	7.8	44	4.9	31	9.4	58	10.5	58	5.5	36
110	9.0	49	5.6	34	10.7	64	11.9	62	6.4	40
120	10.0	53	6.4	39	11.8	69	13.2	66	7.3	45
130	11.2	57	7.3	43	12.9	73	14.5	70	8.3	50
140	12.3	60	8.1	47	14.0	77	15.5	73	9.4	54
150	13.4	63	8.9	51	15.1	81	16.5	76	10.5	59
160	14.5	66	9.9	56	16.1	84	17.4	78	11.6	63
170	15.5	68	10.9	60	17.1	87	18.3	81	12.7	66
180	16.5	70	11.9	64	18.1	90	19.2	83	13.5	69
190	17.5	72	12.7	67	19.1	93	20.0	85	14.3	71
200	18.4	74	13.5	70	20.0	95	20.7	87	15.1	72

[1] Frothingham, E. H.: The eastern hemlock, Bull. 152, F. S., U. S. D. A. pp. 25-27.

TABLE 11.—*Variation in diameter-height relation with habitat.*

LODGEPOLE PINE.[1]

	Diameter in inches.								
	4	6	8	10	12	14	16	18	20
	Heights, in feet.								
Medicine Bow, National Forest, Wyo.	....	....	59	64	69	73	76	....	....
Slope type, Gallatin County, Mont	41	57	66	71	74	76	78	79	81
Flat or creek type, Gallatin County, Mont	40	50	57	63	68	73	77	80	82

[1] Ziegler: Forest tables, Lodgepole pine, *Cir. 126, F. S.*, U. S. D. A. p. 15.

TABLE 11.—*Variation in diameter-height relation with habitat*—Continued.

WESTERN YELLOW PINE.[3]

	Diameter in inches.								
	6	8	12	16	20	24	28	32	36
	Heights, in feet.								
Prescott National Forest, Ariz.	24	30	43	54	65	74	82	87	91
Archuleta County, Colo.	22	31	53	68	79	88	96	102	.....
Black Hills National Forest, S. D.	34	45	62	73	80	86	90	.....	.....
Flathead and Missoula Counties, Mont.	44	54	70	81	91	100	107	114	121
Butte and Madero Counties, Calif.	30	40	60	79	97	112	125	136	144
Stevens County Wash.	.....	.....	.....	.....	110	115	130	142	146

[3] Idem: Forest tables. Western yellow pine, *Cir. 127, F. S.*, U. S. D. A. p. 11.

TABLE 12.—*Variation in height of young seedling hickories of different varieties.*[1]

	Age, years.					
	1	2	3	4	5	6
Shagbark	2.8	4.2	7.8	12.0	17.0	....
Pignut	3.0	5.8	8.0	12.0	17.0	....
Mockernut	3.0	4.7	8.0	12.5	20.0	28.7
Bitternut	3.5	6.3	9.5	13.3	19.5	27.0
Big shellbark	4.3	6.0	11.0	16.0	22.0	....

[1] Boisen and Newlin: The commercial hickories, Bull. 80, F. S., U. S. D. A. p. 27.

TABLE 13.—*Variation in individual trees of Norway pine, in Bayfield County, Wis.*[1]

	Diameter in inches.													
	1	2	4	6	8	10	12	14	16	18	20	24	30	34
	Height in feet.													
Minimum	11	16	21	26	32	38	44	50	55	61	66	76	89	98
Maximum	16	28	52	72	87	97	103	107	109	112	114	117	123	127
Average	12	20	34	47	58	67	74	80	35	88	91	96	104	109

[1] Woolsey and Chapman: Norway pine in the Lake States, Prof. Paper 39, F. S., U. S. D. A., pp. 7-18.

Taking the case of a second-growth white pine in New Hampshire,[4] the constancy of the height-diameter relation and normal density of stand or stock in different habitats is illustrated by the following figures:

Quality 1: Age, 55 years; diameter, 11.8 inches; height, 80.5 feet; 354 trees per acre.

Quality 2: Age, 65 years; diameter, 11.6 inches; height, 79 feet; 348 trees per acre.

Quality 3: Age, 80 years; diameter, 11.7 inches; height, 78 feet; 318 trees per acre.

TREE GROWTH RELATIONS.

Before attempting to apply the water requirement ratio as determined by Höhnel and the author's leaf-weight determinations to practical calculation of transpiration losses, attention will be called to some facts regarding the laws of growth of trees which may throw light on the question of the validity of the assumption that the leaf crop for a given species of tree varies in proportion to the product of trunk diameter and height. The rate of growth of a tree is not in general proportional to its age. In nearly all cases the growth graphs are curved and there seems to be no general form of growth curve applicable to all trees. The rate of growth is a function of the habitat—trees of the same age growing in different locations have widely different diameters and heights. This is well illustrated by the data for hemlock shown in Table 10.

Transpiration loss is proportional to leaf mass of the tree crown. It is therefore desirable to find what evidence there is available in support of the assumption made that the leaf mass is proportional to the product—diameter in inches × height in feet.

TABLE 14.—*Tree crown area and volume relations.*

Species.	Diameter breast high = d.	Crown diameter.	Normal height = h.	Crown height = h_c.	Crown circumference = C_c.	Crown circumference × height.	dh.
	Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Square feet.*	
Beech	1	3	12	7	9.45	66.5	12
	5	13	44	25	40.8	1,020	220
	10	24	72	43	75.4	3,242	720
	15	31	75	45	97.4	4,383	1,125
	20	35	76	45	110.0	4,950	1,520
	25	38	77	46	119.0	5,474	1,925
Sugar maple	1	3	13	6	9.45	56.7	13
	5	13	43	20	40.8	816	215
	10	21	65	31	66.0	2,046	650
	15	27	73	35	84.8	2,968	1,095
	20	32	75	36	100.5	3,618	1,500
	25	38	77	37	119	4,403	1,925
Yellow birch	1	3	15	6	9.45	56.7	15
	5	11	37	15	34.6	519	185
	10	18	61	27	56.5	1,525	610
	15	23	70	31	72.2	2,238	1,050
	20	29	76	35	91.1	3,185	1,520
	25	35	82	38	110.0	4,180	2,100
Basswood[1]	1	3	7.8	4	9.4	37.6	7.8
	5	12	37	17	37.7	641	185
	10	18	65	25	56.5	1,412	650
	15	20	83	30	62.8	1,884	1,245
	20	22	93	32	69.1	2,211	1,860
	25	25	102	34.5	78.5	2,708	2,550

[1] Volume table not available. Normal height given is for yellow poplar.

As already noted, the thickness of the leaf mass increases with age or with diameter and height up to a certain limit at least. In order, then, that the leaf mass should be proportional to the product of diameter times height it is necessary that increase in diameter and height of crown should be somewhat less rapid than increase in diameter and height of tree trunk. The relation of breast-height diameter to crown diameter for Norway pine is illustrated by the following data:

Relation of breast-height diameter to crown diameter, Norway pine in Lake States.[5]

Trunk diameter, inches.	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Crown diameter, feet.	4	5	7	8	9	11	12	13	13	14	15	15	16	16	16	16	16	17	17

It will be noted that for trees up to 13 inches in diameter the crown diameter in feet is approximately 1.2 times the trunk diameter in inches. For further increase in trunk diameter there is, however, not a proportional increase in crown diameter.

In Table 14 data are given relative to the crown diameters and crown heights of four varieties of trees in terms of trunk diameter and trunk height. The normal age of trees of different diameters and heights have been taken

[4] Frothingham, E. H.: White pine, *Bull. 13, F.S., U.S.D.A.*, pp. 21-22.

[5] Cf. footnote to Table 13.

from the Woodsman's Handbook. The trunk and crown diameters and trunk and crown heights for beech trees have been plotted in terms of age as shown on figure 1. The rate of growth in the case of beech increases with age until the tree reaches very nearly its mature height. Growth in trunk diameter continues, though at a slightly diminished rate, long after the tree has reached its full stature. Crown height is nearly a constant percentage of the height of the trunk at all ages. The crown reaches its mature height at about the same age as the trunk.

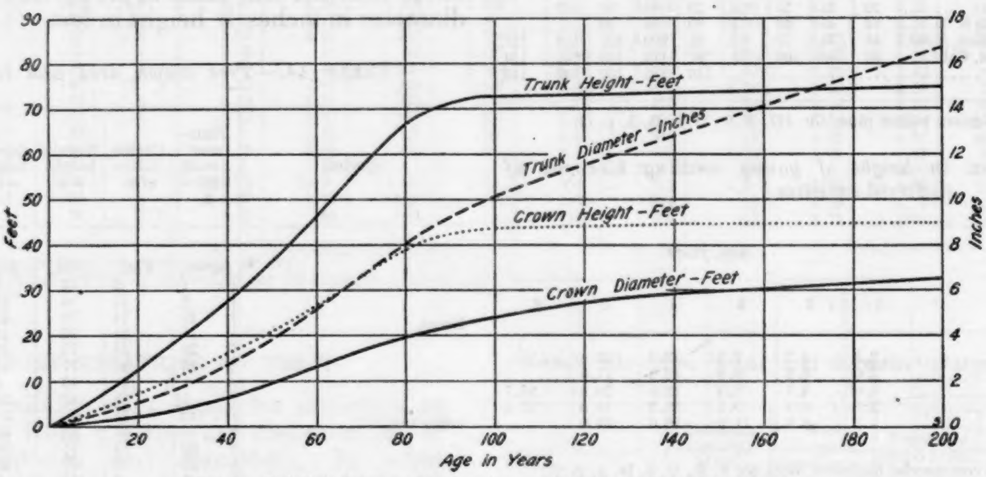

FIG. 1.—Relations between trunk and crown height and diameter and age.

Growth in crown diameter, like growth in diameter of trunk, continues after the tree and crown have reached full height, but growth in crown diameter is relatively slower than growth in trunk diameter after the full height of the tree is attained. In so far as it is possible to generalize from the limited data at present available, it appears that the crown surface is very nearly proportional to the product of trunk diameter times height until the tree reaches its mature height, after which the crown surface increases more slowly than that product; but, as already noted, this is undoubtedly compensated for in part by increase in thickness of the leaf layer. Apparently nothing better can be done at present than to assume the annual weight of leaf crop to be proportional to the product—diameter times height. It is necessary to leave the matter of finding a more precise basis of calculation of transpiration for future determination.

Calculating Forest Transpiration.

Table 15 contains the water requirement ratios for various species of trees as determined by Höhnel, together with the leaf-weight ratio or dry-leaf weight in ounces per inch-foot of the diameter-height product for these trees as determined by the author.

Let L_r = dry-leaf weight, ounces per inch-foot.
d = breast-height diameter of tree in inches.
h = height of tree in feet.
W_r = Höhnel's water-requirement ratio.
T_c = transpiration loss, cubic feet per tree.
T_d = transpiration loss expressed as a depth in inches per acre.
N = number of trees per acre.

Then,

$$T_c = \frac{W_r L_r dh}{16 \times 62.4} = 0.001\ W_r L_r dh \qquad (1)$$

$$T_d = \frac{12\ T_c N}{43{,}560} = \frac{T_c N}{3{,}630} \qquad (2)$$

or

$$T_d = \frac{0.2755\ W_r L_r dh N}{1{,}000{,}000} \qquad (3)$$

Columns 6, 7, and 8 of Table 15 give values of T_d in inches depth on forest area for summer, winter, and the year, respectively, for a value of $dhN = 10{,}000$. Calling these values T_1, then

$$T_d = \frac{dhN}{10{,}000}\ T_1 \qquad (4)$$

TABLE 15.—*Factors for calculating transpiration from trees* [1] (*leaf-crop basis*).

Tree.	Leaf ratio L_r.	Water-requirement ratio = W_r. Höhnel, 1879.			Transpiration, T_1 inches per acre, dhN=10,000.			Average.
		May-October.	November-April.	Year.	May-October.	November-April.	Year.	
1	2	3	4	5	6	7	8	9
Ash	0.364	971	9.8	981	0.974	0.00982	0.984	
Birch	.295	830	18.5	849	.676	.0151	.690	
Beech	.401	1,023	20.4	1,043	1.131	.0226	1.15	
Hornbeam (ironwood)	.391	755	32.5	787	.814	.0350	.850	1.05
Elm	.990	711	27.9	738	1.943	.0762	2.02	
Oak (average)	.646	616	21.3	638	1.098	.0381	1.14	
Maple (average)	.341	565	11.7	578	.533	.0110	.544	
Gray alder	[2] 303	651	27.1	678	.544	.0226	.566	......
Black alder	.303	772	68.1	840	.646	.0568	.703	......
Basswood (linden)	.516	1,011	27.2	1,038	1.44	.0386	1.48	......
Aspen	.199	848	25.6	873	.466	.0141	.480	......
Larch (tamarack)	[3] 1.20	1,120	44.8	1,165	3.698	.1482	3.864	......
Spruce	[3] 1.20	205	36.5	242	.679	.1208	.800	
Fir	[3] 1.20	78	7.8	86	.258	.0259	.284	.393
White pine [4]	.782	100	10.0	110	.216	.0215	.237	
Yellow pine [5]	.740	104	19.0	123	.213	.0389	.251	

[1] From the author's measurements for mature trees. Ounces dry leaves per inch-foot. Trunk diameter ×height.
[2] Assumed same as black alder.
[3] Assumed same as for hemlock.
[4] Höhnel's Scotch pine.
[5] Höhnel's Austrian pine.

TABLE 16.—*Comparative yearly transpiration losses from even-aged full-stocked stands of different ages representing approximate maximum transpiration losses for a given age and species.*

[Numbers, diameters, and heights of trees from U. S. Forest Bureau yield tables. (For evaporative capacity=45 ins.).]

	Age, years.									
	20	30	40	50	60	80	100	120	140	160
Douglas fir, western Cascade foothills on first quality soils. T_1=0.284:										
Trees per acre	990	580	410	340	265	167	115	92	88	....
Diameter, average tree	4.6	6.9	8.9	10.4	12.3	16.5	20.9	24.5	25.9	....
Height, average tree	32	46	59	69.5	82	107.5	134.5	156.5	166	....
dh	147	317	525	723	1,009	1,782	2,800	3,834	4,300	....
Ndh/100	1,455	1,839	2,152	2,458	2,700	2,976	3 220	3,527	3,784	....
T	4.12	5.22	6.11	6.98	7.67	8.45	9.14	10.02	10.75	....
White pine, quality first, second growth. T_1=0.237:										
Trees per acre	1,322	879	583	408	311	207	154	....	....	....
Diameter, average tree	4.0	6.4	8.6	10.8	12.8	16.5	19.8	....	....	....
Height, average tree	24.5	44	61	74.5	85.5	101.5	113	....	....	....
dh	98	282	525	804	1,094	1,675	2,237	....	....	....
Ndh/100	1,196	2,479	3,061	3,280	3,402	3,467	3,445	....	....	....
T	2.83	5.86	7.25	7.77	8.06	8.22	8.16	....	....	....
Red spruce, quality first, normal full-stocked second-growth stands in New Hampshire and Vermont. T_1=0.800:										
Trees per acre	1,294	887	668	558	506	457	417	....	....	....
Diameter, average tree	3.8	5.9	7.5	8.6	9.3	10.1	10.8	....	....	....
Height, average tree	24	36	46	55	61	70	76	....	....	....
dh	91	212	345	473	567	707	821	....	....	....
Ndh/100	1,177	1,880	2,305	2,639	2,869	3,231	3,423	....	....	....
T	9.42	15.04	18.40	21.11	22.95	25.85	27.38	....	....	....
Hickory. T_1 (average hardwood)=1.05:										
Trees per acre	....	700	480	320	230	155	120	100	84	73
Diameter, average tree	....	4.0	5.0	6.2	7.2	9.0	10.5	11.8	12.6	14.4
Height, average tree	....	33	41	49	57	69	78	85	90	94
dh	....	132	205	304	410	621	835	1,003	1,134	1,354
Ndh/100	....	924	984	1,063	943	963	1,002	1,003	925	989
T	....	9.70	10.33	11.16	9.90	10.11	10.52	10.53	9.71	10.38
Beech. T_1=1.15:										
Trees per acre	2,524	1,526	934	598	423	269	196	157	....	....
Diameter, average tree	1.7	3.0	4.5	6.3	7.9	10.7	13.0	15.0	....	....
Height, average tree	18	31.5	44.6	56.1	66.9	84.6	97.1	106	....	....
dh	31	95	201	353	528	905	1,261	1,590	....	....
Ndh/100	782	1,450	1,877	2,111	2,233	2,434	2,472	2,496	....	....
T	8.99	16.6	21.59	24.27	25.68	28.00	28.43	28.64	....	....

Transpiration rate for various kinds of vegetation has been found to bear very nearly a relation of direct proportionality to evaporative capacity. Inasmuch as the annual evaporative capacity, E_c, for the region and conditions where Höhnel's experiments were performed was about 45 inches, it is evident that to obtain the transpiration loss in any region where the evaporative capacity E_c is different the transpiration as calculated by the formulae above given should be multiplied by a factor $\frac{E_c}{45}$.

Finally, the working formula for calculating transpiration depth from forest areas is

$$T_d = \frac{dhN}{10,000} \times \frac{E_c}{45} \qquad (5)$$

The data required are those given in conjunction with ordinary forest cruisers' reports, i. e., d, h, and N, or d and N. N and the age of the forest alone may be used in conjunction with the age-diameter-height relations given in the Woodsman's Handbook.

In Table 16 there are given for various kinds of trees the number and sizes of trees per acre for fully stocked even forest stands. In each case the corresponding transpiration loss for a region where the evaporative capacity is 45 inches has been calculated by means of formula (5). The results are expressed opposite T for each age. In the case of some species of trees on which there were no experiments by Höhnel, the water requirement ratio has been assumed as equal to that for some closely related species, as indicated in the table. Comparison of the values of T for different species and ages of trees shows at once the wide rage of transpiration loss which may take place from different forest areas, dependent upon the composition, density, and age, or development of the forest growth. For spruce and fir, leaf weight determinations for mature trees are wanting and the transpiration values are still somewhat conjectural. As further illustrating the application of the data, calculations of the annual transpiration loss from mixed woodlands where the composition and stand are known are given on Table 17. Here again there are wide variations in the amount of annual transpiration loss, dependent upon the density, character, and stand of the different species of trees. In this calculation it has been necessary to adopt unit values of transpiration loss for a closely related variety or species in many instances. The values adopted are given in column 13 of the table.

Relative to the accuracy of the results obtained by this method of calculating forest transpiration, it may be said that they are at least consistent with what is known of this matter from other sources. In this connection it is to be borne in mind that there are three sources of water losses from a forest area: interception, transpiration, and evaporation from the soil. The interception loss can be determined with considerable accuracy from existing data. Roughly it amounts to about 15 per cent of the rainfall.

TABLE 17.—*Estimated annual transpiration by actual forest stands.*

Locality.	Tree.	Number per acre N.	Diameters.[1]			Average height.[2]	dh.	Ndh.	T_1.	T.	
			From—	To—	Weighted average.						
1	2	3	4	5	6	7	8	9	10	11	12
Spruce, flat, Pittsburgh Township, N. H., virgin forest. E_e=approximately 42 inches.	Spruce	200	2	25	9.26	50	463	92,600	0.800	7.48	
	Balsam fir	275	2	17	4.78	40	191	52,525	.284	1.49	
	Yellow birch	6.2	2	35	10.10	60	606	3,757	.690	.26	
	Paper birch	22.9	2	16	6.99	54	377	7,717	.690	.52	
	Miscellaneous	3.4	2	13	3.06	30	92	313	1.05	.03	T_1 for average hardwood.
	Total									9.78	$9.78\times\frac{42}{45}=9.13$ inches annual transpiration.
Hardwood forest, Waterville Township, N. H. Average hardwood E_e=approximately 42 inches.	Spruce	88.12	2	29	6.95	42	292	25,731	.800	2.06	
	Balsam	10.68	2	15	3.40	28	95	1,015	.284	.03	
	Hemlock	3.78	2	37	16.17	69	1,118	4,226	.542	.23	T_1 for mean of spruce and balsam.
	Yellow birch	40.84	2	42	20.63	76	1,566	63,955	.690	4.41	
	Sugar maple	15.94	2	32	10.04	65	652	10,393	.544	.56	
	Beech	70.62	2	26	8.74	69	603	42,584	1.15	4.90	
	Miscellaneous	20.54	2	20	2.95	30	88	1,808	1.05	.19	T_1 for average hardwood.
	Total									12.38	$12.38\times\frac{42}{45}=11.55$ inches annual transpiration.
Flat, burned over 30 years preceeding, New Hampshire. E_e=approximately 42 inches.	Yellow birch	2			1.0	15	15	30	.690	.002	
	Spruce	22			2.5	20	50	1,100	.800	.088	
	Paper birch	20			3.1	32	99	1,980	.690	.137	
	Aspen	3			3.9	34	133	399	.480	.019	
	Balsam fir	18			4.2	33	139	2,502	.284	.071	
	Red maple	14			3.8	34	129	1,806	.544	.098	
	Striped maple	3			1.0	12	12	36	.544	.002	T_1 for black alder.
	Shadbush	5			1.0	8	8	40	.703	.003	
	Total									.42	$0.42\times\frac{42}{45}=0.39$ inches annual transpiration.
Lodgepole pine, Medicine Bow, Wyo. (Only trees over 4 inches in diameter are included.) E_e=approximately 46 inches.	Lodgepole pine	251.60	4	28	8.98	66	593	149,198	.251	.374	T_1 for yellow pine.
	Engleman spruce	9.06	4	29	9.04	49	443	4,014	.800	.32	
	Alpine fir	7.46	4	20	6.92	40	277	2,065	.284	.059	
	Aspen	.05	4	8	6.00	48	288	144	.480	.007	
	Cottonwood	.01	5	5	5.00	58	290	3	1.48	.0004	T_1 for linden.
	Total									4.126	$4.126\times\frac{46}{45}=4.22$ inches annual transpiration.
Western yellow pine, Madero County, Calif. 5,000 feet elevation. E_e=approximately 60 inches.	Incense cedar	38.45	1	59	17.18	79	1,359	52,253	.284	1.48	T_1 for fir.
	White fir	24.60	1	54	18.00	79	1,422	34,981	.284	.99	Do.
	Western yellow pine	20.65	1	84	21.71	142	3,081	63,622	.251	1.60	
	Sugar pine	19.25	1	84	22.00	108	2,376	45,738	.251	1.15	
	California black oak	2.30	1	39	16.21	72	1,167	2,684	1.14	.30	
	Total									5.52	$5.52\times\frac{60}{45}=7.36$ inches annual transpiration.
Chestnut slope, southern Maryland. E_e=approximately 52 inches	Chestnut	101.57	2	44	10.80	60	648	65,817	1.14	7.51	T_1 for oak.
	Oak	31.57	2	26	8.07	55	444	14,030	1.14	1.60	
	Beech	13.56	2	23	6.12	50	306	4,149	1.15	.48	
	Red maple	9.70	2	13	4.65	42	195	1,891	.544	.10	
	Hickory	9.14	2	10	3.70	28	104	950	1.05	.10	T_1 for average hardwood.
	Sweet gum	6.00	3	18	7.25	68	493	2,958	1.05	.31	Do.
	Yellow poplar	2.57	2	14	4.36	38	166	426	.480	.02	
	Black gum	2.43	2	12	3.63	40	145	352	1.05	.04	Do.
	Scrub pine	2.13	4	12	7.87	56	441	939	.237	.02	
	Miscellaneous	3.12	2	16	5.68	40	227	708	1.05	.07	Do.
	Total									10.25	$10.25\times\frac{52}{45}=11.84$ inches annual transpiration.
Western yellow pine, E_e=approximately 65 inches.	Black jack	13.64	4	36	13.69	65	990	13,503	.251	.34	
	Yellow pine	22.26	7	48	22.39	68	1,562	34,770	.251	.87	
	Total									1.21	$1.21\times\frac{65}{45}=1.75$ inches annual transpiration.
Virgin spruce and fir forest, Maine. E_e=approximately 36 inches.	Spruce	276.4	2	12	5.49	38	209	57,767	.800	4.62	
	Balsam fir	72.0	2	12	5.02	42	211	15,192	.284	.43	
	Total									5.05	$5.05\times\frac{36}{45}=4.04$ inches annual transpiration.
Typical Adirondack forest (Pinchot). E_e=approximately 40 inches.	Spruce	31.40			13.0	65	845	26,533	.800	2.12	
	Birch	14.00			17.1	71	1,214	16,996	.690	1.17	
	Beech	10.00			13.2	72	950	9,500	1.15	1.09	
	Hard maple	6.10			13.9	71	987	6,021	.544	.33	
	Hemlock	4.60			16.7	70	1,169	5,377	.542	.29	T_1 for average spruce and fir.
	Balsam	4.20			11.4	61	695	2,919	.284	.083	
	Soft maple	2.60			13.6	72	979	2,545	.544	.138	
	White pine, Ash, Cedar, Cherry	.54	Av.	15.3	18.4, 12.9, 14.5, 15.3	72	1,101	594	.393	.022	T_1 for average spruce, fir, and pine.
	Total									5.24	$5.24\times\frac{40}{45}=4.66$ inches annual transpiration.

[1] Diameter in inches.

[2] Height in feet.

TABLE 18.—*Seasonal distribution of transpiration. Höhnel's 1879 experiments.*

Tree.	Per cent of seasonal total, June-September.			
	June.	July.	August.	September.
Ash	23.0	28.0	29.4	18.9
Birch	19.9	28.6	36.8	14.5
Beech	24.5	29.0	30.0	16.6
Hornbeam or ironwood	16.4	28.8	32.9	21.7
Elm (field)	24.4	26.4	29.9	19.0
Oak ("Stiel" and "Trauben")	19.4	22.8	30.5	27.0
Oak ("Zerr")	17.9	25.2	36.7	20.5
Spruce	24.1	31.1	29.0	16.0
Fir	20.0	27.5	30.8	21.5
Pine (Scotch white)	20.0	27.5	28.1	23.8
Pine (black Austrian)	23.5	24.8	26.9	18.3
Average	21.2	27.2	31.0	19.8
Höhnel's measured evaporation, 1879, per cent	27.2	25.9	26.5	20.5

Evaporation from the soil surface can also be approximately determined. The total water losses are known for many areas from a comparison of the measured run-off and precipitation.

The leaf-weight ratios used in Table 15 are those for the larger trees where available. Values for larger trees were used instead of an average of those for large and small trees, because determinations of transpiration losses from larger trees are those most generally described. Comparing the leaf-weight ratios, column 9 of Tables 8 and 9, for large and small trees, it will be found that the ratios for young trees are generally, though not always, considerably the larger. In other words, trees of less than 10 years of age have more leaf weight per unit of diameter times height than mature trees. The method of calculation here used, based on leaf-weight data for mature trees, apparently leads to too small values of estimated transpiration when applied to very young trees. No certain method of correcting for this factor is at present available. In view of the fact that the thickness of the leaf layer in the tree crown becomes more nearly constant after the tree has reached a moderate size and the crown begins to have a core or hollow center, it may be fairly presumed that this error is not involved except in comparatively young trees.

A determination of the ratio $\frac{\text{dry leaf weight}}{\text{diameter} \times \text{height}}$ was made in general for only one large tree of each kind. Better results would no doubt be obtained by averaging a large number of trees of the same size and species. Furthermore, it is desirable that such investigations should be carried out for various sizes or ages of trees of the same species. In spite of the necessity of cutting down many trees and the great amount of labor involved in a leafage determination, even for a single tree, it is to be hoped that extensive data along the lines above suggested may be obtained in the near future.

Forest transpiration is of course limited by available water supply derived from precipitation. However, this is automatically taken into account in a large measure, since the type of forest which will grow on a given area and the size attained by the trees is conditioned by rainfall and other environmental factors. While a transpiration loss of 25 inches or more may occur in a full-stocked mature beech forest under favorable conditions, the existence of such a forest stand is proof positive of rainfall sufficiently abundant to support it and to provide the corresponding transpiration and other water losses. In another region with materially lower rainfall an equally dense stand of beech would not be found.

The seasonal transpiration losses can be distributed throughout the different months by taking the transpiration for each month as proportional to the ratio of the evaporative capacity for the given month to the total for the season. The relation between the two as determined by Höhnel's experiments is shown for the growing season, June-September, in Table 18. Separate calcultaions should be made for the growing and dormant seasons because the ratio of transpiration to evaporation rate is higher during the growing than during the dormant forest season. The months of May and October are transition periods for which the ratios of transpiration to evaporation are about midway between their winter and summer values.[6]

[6] Other references on this subject are:
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NOTES ON THE 1922 FREEZE IN SOUTHERN CALIFORNIA.

By FLOYD D. YOUNG, Meteorologist.

It is safe to say that a winter never passes without the occurrence of frost somewhere in the citrus-growing sections of southern California. During many winters, however, the temperature in these districts does not fall low enough to damage citrus fruits. In other winters the damage is slight and is confined to samll areas in the colder localities. In mild winters the light frosts are looked upon by the fruit growers as beneficial, serving to improve the color and flavor of the navel orange.

At intervals of about 10 years, on the average, general heavy freezes have visited the citrus districts, damaging the fruit and trees to the extent of many millions of dollars. These "freezes" partake more of the nature of a cold wave than a frost; in fact, the freeze is a combination of cold wave and frost. A wave of low temperatures advances southward from the Canadian border, on the southern and southwestern borders of a well-developed high-pressure area. A strong, cold northerly wind prevents the normal rise in temperature during the day. When this wind dies out in the evening, the temperature falls with startling rapidity, owning to the low humidity which prevails in southern California under these conditions of pressure distribution.

Strong temperature inversions develop on hillsides and slopes in the citrus districts on calm, frosty nights, but during a freeze differences in temperature between hillside and valley floor are usually slight. The most important factor in limiting or preventing damage during a freeze is the occurrence of a steady wind which continues to blow throughout the night.

Temperatures low enough to damage seriously citrus fruits over a considerable area in southern California occurred in 1913, 1918, and 1922. Freezes occuured in 1913 and 1922, and a serious frost occurred in 1918. In 1913 and 1922 orchards on the higher ground suffered as much damage, in general, as those on the low ground, while in 1918 orchards on the slopes escaped with little or no damage. Some remarkable differences between

minimum temperatures at the bases and on the slopes of hills were recorded during the severe frosts of 1918. On one of the colder nights of this season, a minimum temperature of 21° F. was recorded at the base of a hill, while the minimum temperature at a point 225 feet above, on the slope, was 49° F. On the coldest night in 1922 the difference in minimum temperature between the same two stations was 9° F., the minimum at the base being 18° F. and that at the 225-foot station 27° F. These two stations were about one-half mile apart in a straight line.

THE 1922 FREEZE.

As a general rule, the growth of citrus trees is checked in the fall by cool weather, and the trees remain in a semidormant condition during the winter. While in this condition they are quite resistant to cold. November and December, 1921, and the first half of January, 1922, were unusually free even from light frosts. Mild, rainy weather prevailed during this period, and orange and lemon trees put on much new and succulent growth, making them especially susceptible to damage by low temperature. No serious, widespread damage by low temperature had occurred later than January 15 within the memory of the fruit growers, and this, together with the exceptional mildness of the season up to that time, had thrown them off their guard. Many growers with full orchard-heating equipment were unprepared for the cold that followed.

On the morning of January 18, 1922, a large HIGH, over the extreme northwest, was showing increased intensity, and was pushing southward in the wake of a well-developed LOW, central over Arizona and New Mexico. Temperatures were falling rapidly over Washington, Oregon, and Nevada, and had fallen slightly in California. The evening weather map of the 18th showed a great fall in temperature over northern California, with temperatures below freezing at 5 p. m. in the upper Sacramento Valley. On the morning of the 19th, the HIGH had increased in intensity and had moved farther south, causing 24-hour temperature falls of from 6 to 18° F. in northern California, and 22 to 24° F. in Nevada. At 5 a. m. Pacific time the temperature was 32° F. or lower throughout northern California, including the coast stations. At the same time the temperature was −14° F. at Winnemucca, and −8° F. at Tonopah, Nev. The evening weather map of the same date showed the positions of the HIGH and LOW practically unchanged since morning, and current temperatures but little lower than on the previous night.

During the night of the 19th–20th, the HIGH increased in size and pushed southward, and on the morning of the 20th the LOW had filled up and disappeared. This night was the beginning of the freeze in southern California, which continued in some localities for five consecutive nights.

LOCAL ASPECTS OF THE FREEZE.

In the great valley of southern California (see fig. 1) the sky was overcast on January 19, with a disagreeably cool northeasterly wind. At the 4:40 p. m. observation at Pomona the temperature of the dew point was 12° F. At that time the weather was clear at Los Angeles, 30 miles to the westward, and a little later the sky cleared at Redlands, about 30 miles east of Pomona, but cloudiness continued at Pomona until about 6:30 p. m. Throughout the great valley the temperature fell rapidly as soon as the sky cleared. Because of the low dew point the rapid fall was not checked until about midnight, when the temperature had reached 21°, and then only because of light, intermittent puffs of wind.

In probably 90 per cent of the winter frosts in southern California the evening dew point is above 28° F. On such nights there is a rapid temperature fall in the early evening, until the dew point is reached, after which there is a slow fall, or a stationary temperature for an hour or longer. For this reason fruit growers who could not be reached with a warning, knowing nothing of the low dew point, felt no concern over the rapidly falling temperature. Many growers who had very complete frost-fighting equipment lost their crops through failure to begin firing early enough in the evening on January 19.

Throughout the period of the freeze there was a rather strong barometric pressure gradient from north to south. This was especially true of the night of the 19th–20th, which was the coldest night of the freeze in the sections immediately south of the San Gabriel Mountains. On the summit of Mount Wilson, elevation 5,850 feet, the average wind velocity during the period from 7 p. m. on the 19th to 7 a. m. on the 20th was 23 miles per hour. In valleys extending north and south this wind was unobstructed, and continued to blow all night, practically without cessation, preventing the development of temperature inversions, and maintaining the temperature at a point high enough to prevent serious damage.

The San Gabriel Mountains, which extend in an east-west direction on the north side of the San Gabriel Valley, acted as a very effective windbreak, and in the northern half of this valley only light, shifting breezes were felt, with long intervals of practically complete calm. This produced an almost ideal condition for a rapid temperature fall and unusually low temperatures. Minimum temperatures as low as 18° F. were registered in standard Weather Bureau instrument shelters in orange groves in the San Gabriel Valley on this night. Figure 1 shows the location of temperature stations by numbers and Table 1 shows minimum temperatures at all stations in operation, for the two coldest nights of the freeze.

TABLE 1.—*Minimum temperatures in southern California on nights of January 19–20 and 20–21, 1922.*

(Locations of stations shown in fig. 1.)

Station number.	January— 19–20	January— 20–21	Station number.	January— 19–20	January— 20–21
	°F.	°F.		°F.	°F.
1	25	29	30	26	24
2	22	25	31	29	34
3	21	24	32	27	27
4 [1]	15	23	33	25	27
5	32	31	34	30	24
6	25	23	35	24	25
7	27	25	36	23	26
8	29	31	37	25	22
9	23	24	38	27	34
10	18	21	39	23	20
11	22	22	40	23	23
12	18	18	41	22	23
13	27	34	42	25	19
14	20	21	43	24	23
15	23	23	44	24	22
16	20	24	45	28	26
17	21	24	46	26	31
18	24	23	47 [1]	3	10
19	26	23	48 [1]	7	13
20	24	25	49	21	22
21	31	28	50	21	23
22	30	33	51	19	27
23	24	24	52	20	23
24	23	24	53	19	20
25	25	19	54	20	23
26	28	22	55	20	23
27	23	25	56	20	23
28	22	24	57	22	25
29	29	24	58 [1]	8	13

[1] These stations located near the summit of the mountain ranges on the north side of the valley.

NOTE.—At stations located in the line of the strong surface wind, as indicated by the arrows in Figure 1, the temperature fluctuated up and down all night, and the duration of the minimum temperature was very short, in some cases only 2 or 3 minutes. At other stations, the fall in temperature was steady all night, with duration below the danger point for citrus fruits of 14 to 15 hours in extreme cases.

(To face p. 582.)

FIG. 4.—Navel orange grove showing excellent condition of trees and fruit, which were protected with forty 7-gallon Scheu high-stack cast-iron oil orchard heaters to the acre.

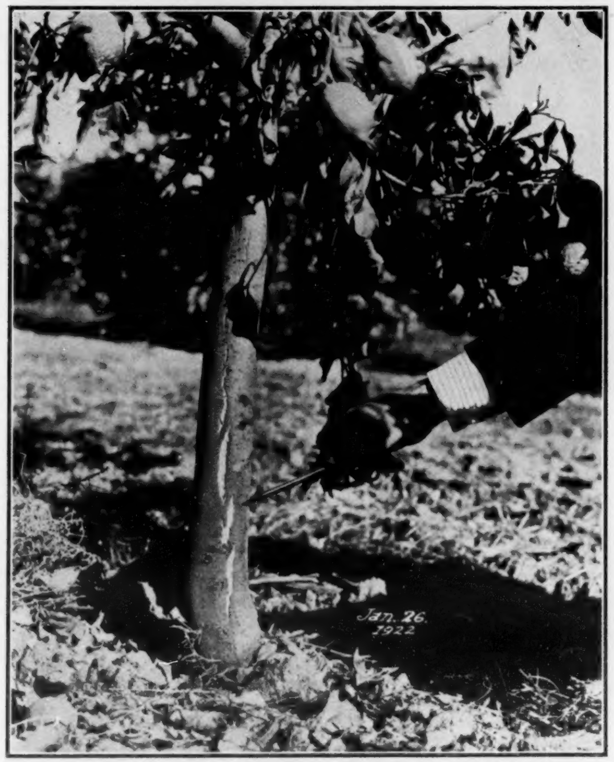

FIG. 2.—Bark of bearing lemon tree split by low temperatures

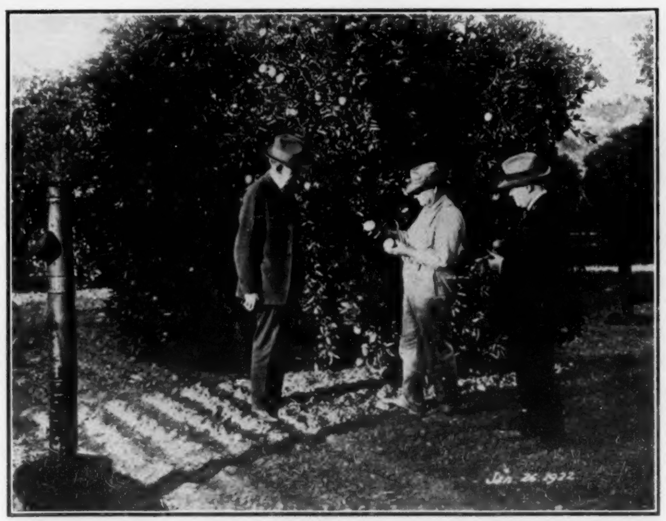

FIG. 5.—View in orange grove in which only outside fruit or on border rows of trees showed damage from frost. The firing in this grove was poorly done, and there is no doubt that there would have been no damage had the work been properly done.

FIG. 3.—Navel orange tree in an unprotected grove. Practically entire crop on the ground and all the fruit showed frost damage. Note curled and dried leaves on outside of tree.

FIG. 6.—General view of an unprotected grove with damaged trees.

FIG. 7.—Frozen orange dump, near Ontario, Calif., June 17, 1922.

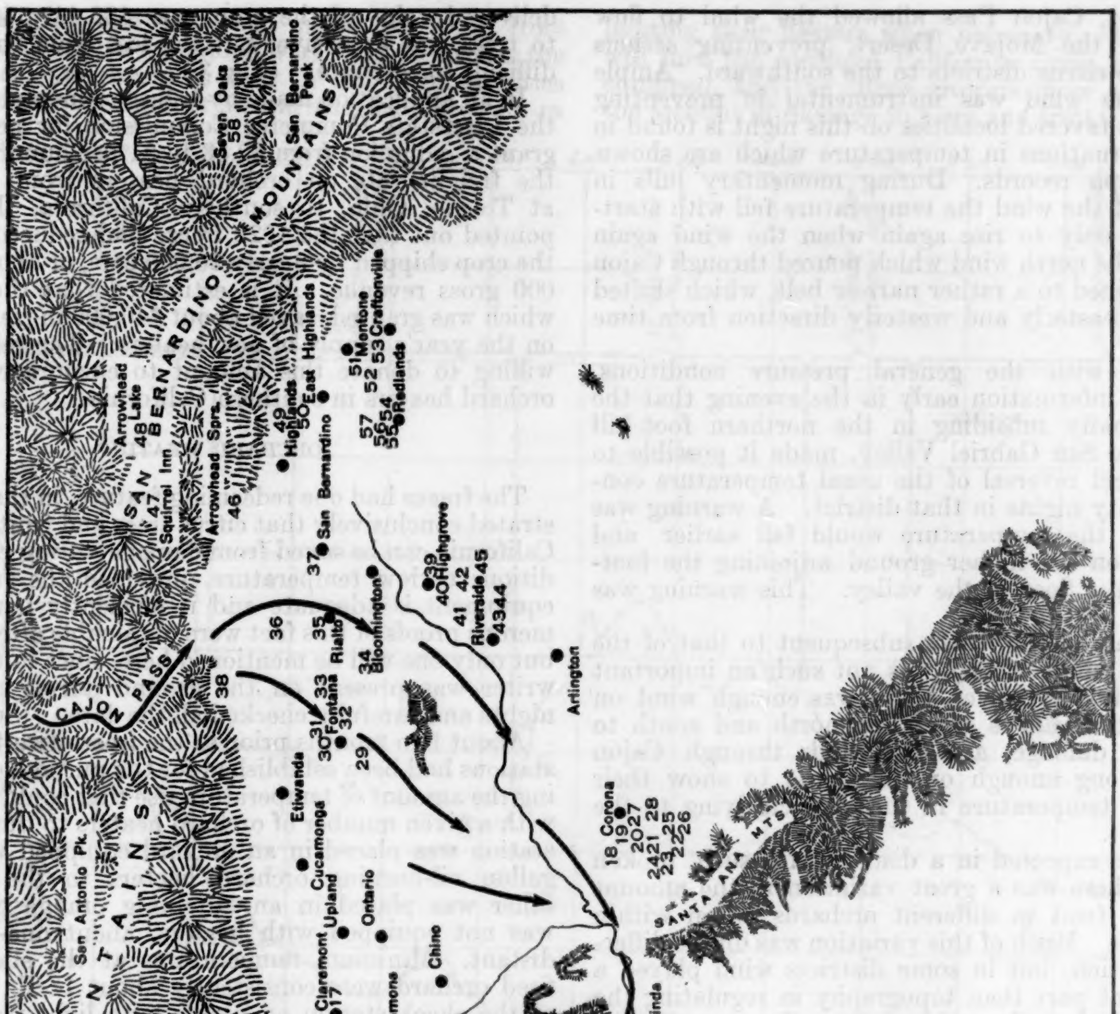

FIG. 1.—Sketch map of the Great Valley of Southern California and surrounding country showing the location of all stations where dependable records were kept. Numbers refer to stations, minimum temperatures at which are given in Table 1.

Farther east, Cajon Pass allowed the wind to flow through from the Mojave Desert, preventing serious damage in the citrus districts to the southward. Ample proof that the wind was instrumental in preventing damage in the favored localities on this night is found in the rapid fluctuations in temperature which are shown on thermograph records. During momentary lulls in the velocity of the wind the temperature fell with startling rapidity, only to rise again when the wind again freshened. The north wind which poured through Cajon Pass was confined to a rather narrow belt, which shifted slightly in an easterly and westerly direction from time to time.

Familiarity with the general pressure conditions, together with information early in the evening that the wind was rapidly subsiding in the northern foot hill sections of the San Gabriel Valley, made it possible to forecast a direct reversal of the usual temperature conditions on frosty nights in that district. A warning was sent out that the temperature would fall earlier and more rapidly on the higher ground adjoining the foothills than on the floor of the valley. This warning was fully verified.

On the nights of the freeze subsequent to that of the 19th–20th the wind velocity was not such an important factor generally. However, there was enough wind on all nights in the valleys extending north and south to prevent great damage, and the winds through Cajon Pass were strong enough on all nights to show their effects on the temperature in the districts lying to the south and west.

As might be expected in a district with such broken topography, there was a great variation in the amount of damage to fruit in different orchards, often within short distances. Much of this variation was due to differences in elevation, but in some districts wind played a more important part than topography in regulating the temperature during the cold nights. In general, districts without obstructions for several miles to the northward which would break the force of the wind escaped with comparatively little damage. On the other hand, in at least one district almost within view of the Pacific Ocean, but sheltered on the north and east by high hills, temperatures were low enough to split the bark on the trunks of bearing lemon trees. (Fig. 2.)

DAMAGE CAUSED BY 1922 FREEZE.

Damage to fruit throughout the citrus sections was enormous in the aggregate. In hundreds of groves the entire crop was lost. Unusually high prices were received for the marketable portion of the crop, so that the total returns did not correctly indicate the amount of damage. California Fruit Growers' Exchange officials state that 53 per cent of a normal crop of oranges brought 90 per cent of the average returns. The gross returns for the 1921 citrus crop f. o. b. California were $83,537,344. The 1922 crop was larger than the 1921 crop, and the fruit was of better quality, prior to the freeze. Including fruit marketed prior to the freeze, the total gross returns for the 1922 crop were $71,366,464. Using these figures as a basis, this would indicate a loss to the industry of more than $12,000,000. If this $12,000,000 had been equitably distributed among all the growers of citrus fruits, the strain would not have been great. As a matter of fact, however, growers who protected their crops, and those located where the cold was not so severe, received unusually large returns, while many others received nothing. The loss to the country at large, based on the delivered value of the crop, was $32,437,574. Damage to trees was extensive, but the loss from this source is difficult to estimate. (Fig. 3.)

In an application made by transcontinental railroads to the Interstate Commerce Commission for permission to grant a reduction from $2.33 to $1 per hundredweight in the freight rate on orchard heaters from the factory at Toledo, Ohio, to southern California, the railroads pointed out that the 1922 freeze had reduced the size of the crop shipped by nearly 20,000 cars, or about $10,000,000 gross revenue. It is estimated that the reduction, which was granted, saved about $40,000 in freight charges on the year's supply of new heaters. The railroads were willing to donate this amount to encourage the use of orchard heaters in southern California.

ORCHARD HEATING.

The freeze had one redeeming feature, in that it demonstrated conclusively that citrus trees and fruit in southern California can be saved from damage during extreme conditions of low temperature, provided the frost-fighting equipment is adequate and is efficiently handled. Numerous proofs of this fact were obtainable after the freeze, but only one will be mentioned here, since in this case the writer was present on the ground during all the cold nights and carefully checked all the data. (See figs. 4–7.)

About two months prior to the freeze two temperature stations had been established for the purpose of determining the amount of temperature rise that could be obtained with a given number of orchard heaters to the acre. One station was placed in an orchard equipped with fifty 7-gallon oil-burning orchard heaters to the acre. The other was placed in an adjoining orange grove which was not equipped with heaters, about one-fourth mile distant. Minimum temperatures at the station in the fired orchard were consistently about 1° F. higher than at the check station on nights with light frosts, but on the night of the 19th-20th there was little temperature inversion and temperatures at nearly all stations in the same general locality ran about the same. Temperatures at these two stations were practically identical on the evening of the 19th, up to the time the heaters were lighted.

The actual temperature records secured at these two stations, using special 29-hour thermographs, carefully checked at intervals of about 15 minutes throughout most of the night, are shown herewith. (Fig. 8.) The temperature station in the fired grove was placed as far from any orchard heater as possible.

Due to the mild season and the late date at which the freeze began, the owner of the fired orchard had allowed the oil supply in his storage tanks to become depleted, so that he had no oil available for refilling his heaters when they burned out in the morning, at the time the outside temperature was at about its lowest point. During the three or four coldest hours of the night he was left with only one-half his heaters burning. Notwithstanding this fact, only 4.5 per cent of the fruit in the fired grove proved to be unmarketable because of frost damage. The trees were not injured, and many fresh, undamaged orange buds and blossoms were found on the following day. In the unfired orchard, where the check temperature station was located, the crop was a total loss, the trees were defoliated, and there was some cracking of the bark on large branches.

The numerous examples of the value of orchard heating served to increase the interest in frost protection. Heaters were purchased to equip thousands of acres of

citrus trees that had not been protected from frost damage previously, conventions were held to discuss the frost menace, and business men in some communities banded themselves together to aid the fruit growers in lighting their heaters when necessary. The next freeze will find the southern California citrus orchards better equipped, and the citrus growers more alert, to reduce the amount of damage to trees and fruit.

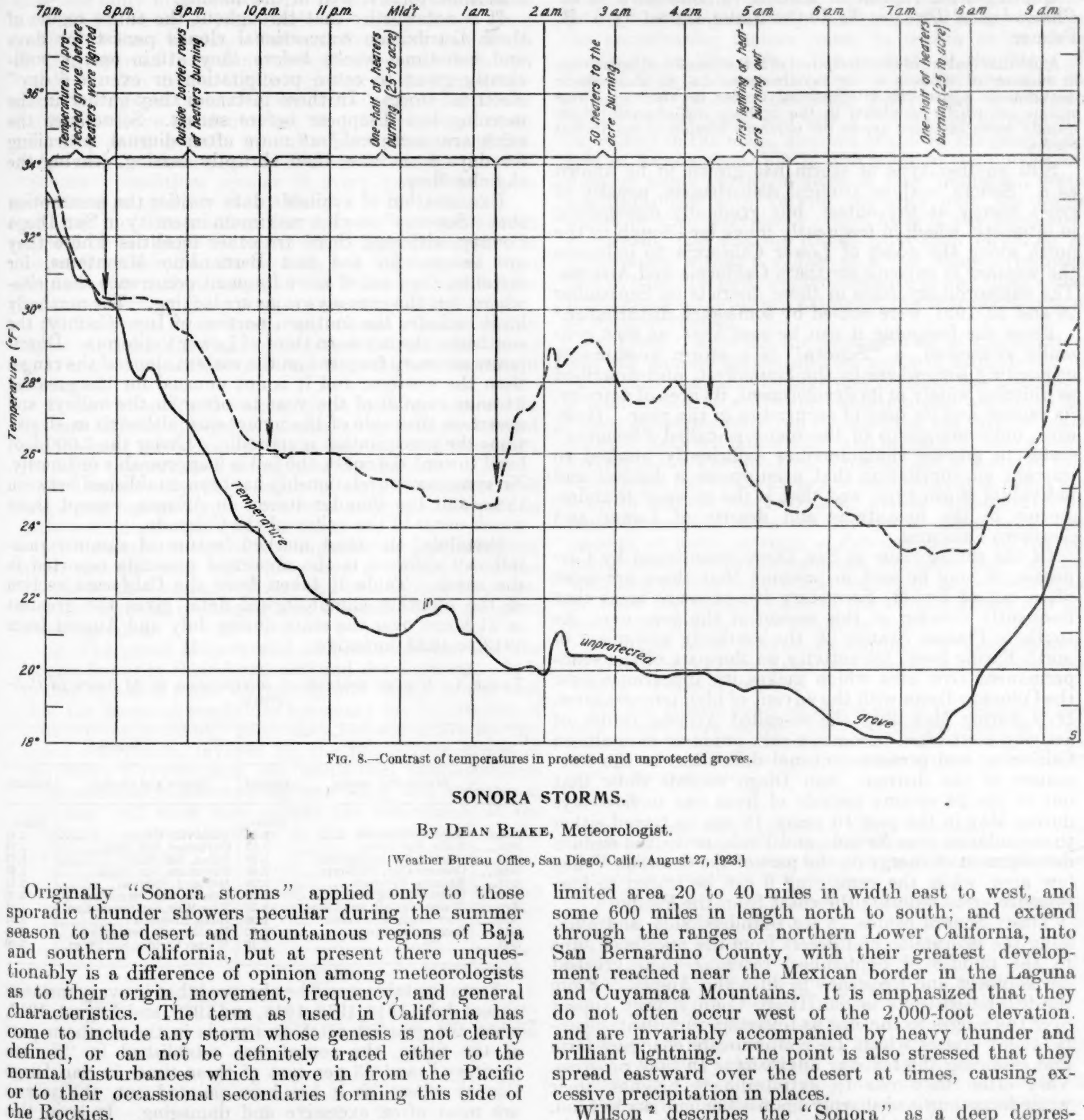

FIG. 8.—Contrast of temperatures in protected and unprotected groves.

SONORA STORMS.

By DEAN BLAKE, Meteorologist.

[Weather Bureau Office, San Diego, Calif., August 27, 1923.]

Originally "Sonora storms" applied only to those sporadic thunder showers peculiar during the summer season to the desert and mountainous regions of Baja and southern California, but at present there unquestionably is a difference of opinion among meteorologists as to their origin, movement, frequency, and general characteristics. The term as used in California has come to include any storm whose genesis is not clearly defined, or can not be definitely traced either to the normal disturbances which move in from the Pacific or to their occassional secondaries forming this side of the Rockies.

According the Archibald Campbell,[1] "Sonora storms" received their name from the old Spanish or Indian settlers of Lower California, who supposed that they began in and spread out from the State of Sonora across the Gulf of California on the mainland. He is responsible for the statement that they form during July, August, and early September only; prevail over a limited area 20 to 40 miles in width east to west, and some 600 miles in length north to south; and extend through the ranges of northern Lower California, into San Bernardino County, with their greatest development reached near the Mexican border in the Laguna and Cuyamaca Mountains. It is emphasized that they do not often occur west of the 2,000-foot elevation. and are invariably accompanied by heavy thunder and brilliant lightning. The point is also stressed that they spread eastward over the desert at times, causing excessive precipitation in places.

Willson[2] describes the "Sonora" as a deep depression extending northward during the fall months from Mexico through the interior of California, western Arizona, and southern Nevada, with the rains occurring generally in the form of thunderstorms. On the other hand, Carpenter[3] associates the "Sonora" with the sudden storms of spring on the southern California

[1] MO. WEATHER REV., October, 1906, p. 461.

[2] *Weather Forecasting in the United States*, p. 337.

[3] Climate of San Diego, Calif., pp. 10, 32; *Bulletin L*, p. 81.

coast, but makes no specific mention of any accompanying electrical phenomena. He assumes that they are overflows from Arizona disturbances, or have their inception in unchartered regions to the south.

Quoting from reprint of section 13, *Summary of the Climatological Data for the United States*, signed by A. H. Palmer:

A peculiar feature of the precipitation is the occasional occurrence in summer of showers of the Sonora type, due to atmospheric disturbances across the international border in Mexico. These storms are wholly unrelated to the cyclonic disturbances which usually move eastward across the northern portion of the United States.

Still another type of storm has grown to be known as a "Sonora"—those tropical disturbances, usually of great energy at the outset, but gradually diminishing in intensity, which in frequently move far enough to the north along the coast of Lower California to influence the weather in extreme southern California and Arizona. The extraordinary rains in these districts on September 29 and 30, 1921, were caused by some such disturbance.[4]

From the foregoing it can be seen that, as now generally conceived, a "Sonora" is a storm presumably originating somewhere in the Southwest, and described as differing widely in its development, its area of activity, its causes, and its time of occurrence in the year. However, only one group of the many so-called "Sonoras" seems to possess characteristics sufficiently marked to warrant an appellation that presupposes a distinct and individual storm type, and that is the summer thunderstorms in the mountains and deserts of Lower and Southern California.

Of the spring rains at San Diego, mentioned by Carpenter, it may be said in passsing that these are most often caused by: (1) Secondary low-pressure areas that frequently develop at this season of the year over the southern Plateau States; (2) the southerly movement of north Pacific lows; (3) activity on the part of the semipermanent LOW area which makes its appearance over the Colorado Basin with the advent of high temperatures. It is during May that the so-called Arizona center of activity most often becomes a rain producer in southern California, and presents unusual difficulties to the forecasters of the district. San Diego records show that out of the 24 stormy periods of from one to five days during May in the past 10 years, 18 can be traced either to secondaries over Nevada and Utah, or to the sudden development of energy on the part of the Colorado Valley low area, while the remaining 6 can be traced to low-pressure areas entering the coast from the Pacific.

True "Sonora clouds"[5] are thunderclouds, and overhang the mountains and desert from the middle of June to the middle of September, reaching their greatest development and frequency in July and August. From the littoral districts in San Diego County, they appear over the ranges to the east as towering, turbulent, gigantic cloud masses which are continuously changing form and assuming the familiar anvil shape as they progress. Very often they rise to extraordinary heights, their white forms outlined sharply against the blue sky beyond, but from first to last they have practically all of the characteristics of the ordinary "thunderhead."

Their appearance is first indicated when small white wisps of cloud are noted, sometimes as early as sunrise, but usually between 9 and 11 a. m., which very quickly take on the cumulus form. Soon a line of flat-based cumuli can be discerned following the general trend of the mountain crests, that is, in a northerly-southerly direction. In less than an hour their true nature becomes apparent, and before the end of the second hour, a thunderstorm is well in the making.

It is noteworthy that throughout the entire region of their distribution convectional clouds persist for days and sometimes weeks before they attain energy sufficiently great to cause precipitation or even a "dry" electrical storm. In these instances they gather in the morning but disappear before sunset. Sometimes the rains are nocturnal but more often diurnal, prevailing for days at a time, then abruptly ceasing, leaving the sky cloudless.

Examination of available data verifies the assumption that "Sonoras" reach a maximum intensity in San Diego County, although there are other localities where they are severe. In the San Bernardino Mountains, for instance, they are of more frequent occurrence than elsewhere, but the excessive rains are lacking. The northerly limit includes the southern portion of Inyo County; the southerly, the northern third of Lower California. Downpours are more frequent on the eastern slope of the ranges than the western, and it is not unusual for the greatest 24-hour rainfall of the year to occur in the valleys and desert on that side of the mountains, although in all sections the precipitation is sporadic. Under the 2,000-foot level toward the coast, the fall is inappreciable ordinarily. No synchronous relationship has been established between these and the thunder storms in Arizona, except those which occur in the valley of the Colorado.

Certainly, the most marked feature of summer rainfall in California is the abnormal amounts reported in the south. Table 1, taken from the California section of the monthly climatological data, gives the greatest in 24 hours over the state during July and August from 1913 to 1922, inclusive.

TABLE 1.—*Greatest amounts of precipitation in 24 hours in California.*

Year.	July.		August.	
	Station and county.	Amount.	Station and county.	Amount.
		Inches.		*Inches.*
1913	Macdoel, Siskiyou	2.15	Glennville Kern	1.61
1914	Nellie, San Diego	3.75	Cuyamaca, San Diego	1.33
1915	Bagdad, San Bernardino	1.29	Julian, San Diego	1.73
1916	Crescent City, Del Norte	2.46	Cuyamaca, San Diego	1.97
1917	Elsinore, Riverside	2.00	McCloud, Siskiyou	1.13
1918	Tamarack, Alpine	1.58	Needles, San Bernardino	2.20
1919	Warner Springs, San Diego	1.26	Rose Mine, San Bernardino	1.61
1920	Fort Bragg, Mendocino	1.36	Indio, Riverside	3.61
1921	Campo, San Diego	2.90	Needles, San Bernardino	2.10
1922	Do	7.10	Warner Springs, San Diego	2.00

From the table it will be observed that in every instance except July, 1913, 1916, 1918, and 1920, and August, 1917, when the greatest catch was made in the northern part of the State, the record was established in "Sonora territory," and 53 per cent of these times in San Diego County where, as it has been pointed out, the storms are most often excessive and damaging. It is in this county that phenomenally heavy rainfalls have been recorded, the most notable of which was at Campo on August 12, 1891, when 11.50 inches was measured at the end of 80 minutes during a "cloudburst." How sporadic these showers are may be judged when we are informed that repeated cases have been known to occur with an inch or more in a restricted locality, and not a drop at a distance of a few miles.

[4] *Pilot Chart of Central American Waters*, April, 1923. (Hurd.)
[5] *Descriptive Meteorology*, Moore, p. 192.

Very often highways, railroads, and bridges are washed away, and arroyos are turned into booming streams, small farms in the river beds are inundated, and the comfort and pleasures of the many campers in the mountains are sadly interfered with. In addition, the accompanying lightning is responsinle for many forest fires; in 1922 in the Cleveland National Forest 14 out of the 39 fires reported from June to September were definitely traced to this cause. Although few actual measurements have been taken, Nelson's investigations in Lower California[6] leave no doubt but that the region of these torrential rains extends into the Sierra Juarez and San Pedro Martir Mountains, and there is ample proof of "Sonora" conditions similar in every respect to those prevailing on this side of the line.

A study of the readings for the past two years from more than 115 gages scattered throughout Imperial, San Diego, Riverside, San Bernardino, Los Angeles, and Inyo Counties was undertaken, and the following conclusions drawn concerning the storms we are considering:

(1) They are more severe and obtain oftener at the higher stations, although some places in the desert have an average comparable with that of the highest mountain exposures.

(2) Elevation for elevation, slope for slope (except in the San Gabriel Range, which has an east to west trend and lies near the ocean), both the amounts and frequency are fairly proportional throughout the district.

(3) Occasionally they occur in early September and late June, but as a rule have little energy, and result in little precipitation in these months.

(4) Unsettled weather, accompanied by local showers, often prevails over the whole area involved, from the Pacific to the Colorado River, and it is during these periods of regional cloudiness that excessive falls are most often recorded.

(5) The great Mojave and Colorado Deserts are the largest factor in their formation and development. It is in this vast arid waste and contiguous ranges to the west that the essential conditions necessary for the genesis of such storms is found. Here they become active by vigorous convection, favored by the precipitous slopes of the Sierra Nevada, with the result that thunderstorms of exceptional violence spring into being, and a glance at the map will show how closely the boundaries of the "Sonora" agree with those of the deserts, both to the north and south.

TABLE 2.—*Amount of precipitation and number of days with 0.01 inch or more at selected stations in southern California during July and August, 1921 and 1922.*

Station.	Elevation (feet).	Precipitation.				Number of days.			
		July, 1921.	August, 1921.	July, 1922.	August, 1922.	July, 1921.	August, 1921.	July, 1922.	August, 1922.
San Diego	87	T.	T.	0.01	T.	0	0	1	0
Los Angeles	293	T.	T.	T.	0.00	0	0	0	0
El Cajon	482	T.	0.07	.04	.01	0	1	1	1
San Bernardino	1,054	0.00	.00	.02	.02	0	0	2	1
Campo	2,543	5.30	.60	7.10	1.32	3	1	1	3
Warner Springs	3,165	1.53	2.03	1.53	2.35	2	5	2	3
Independence	3,957	.06	.08	.02	.39	3	1	1	4
Cuyamaca	4,677	1.81	.07	.57	1.53	3	1	1	5
Squirrel Inn	5,280	T.	T.	5.01	.00	0	0	1	0
Mount Wilson	5,704	.03	T.	T.	T.	1	0	0	0
Decker's ranch	5,850	.52	1.67	.13	.73	4	5	4	9
Rose mine	6,867	1.43	2.50	2.67	.61	2	6	5	4
Raywood Flat	7,200	1.83	.58	.48	.48	6	3	4	5
Indio	−20	T.	.72	.07	T.	0	2	1	0
Calexico	0	.06	2.84	.78	T.	1	2	1	0
Needles	477	.09	3.79	.01	1.47	2	6	1	8

[6] E. W. Nelson: *Memoirs of the National Academy of Science*, Vol. XVI, first memoir.

Before this paper was begun, it was believed that the rains in some way resulted from disturbances originating in Mexico, probably in the Tropics, but until more tangible evidence is obtained it is impracticable to assume any such hypothesis. They are limited to a well-defined and comparatively small area, and in my opinion the contributing factors must be within or in close proximity to this area. The position of the State of Sonora, lying as it does directly south of Arizona, with its contour of ground embracing desert and mountains similar to that State, and with a climate also corresponding closely in the main, disposes of this as the generating field of local storms 500 to 800 miles to the northwest. Another point worthy of stress is that "Sonoras" occur simultaneously with varying intensity over the whole region of their prevalency; have little if any horizontal movement, and run the course from their inception to termination within a radius of a few miles. Granting this as true, it is hard to give credence to any theory that presupposes a northward extension of the tropical system of summer rainfall.

In Lower California the configuration of the country, and the climate in the district north of latitude 29° is practically the same as that just north of the boundary. A diminution of winter precipitation and a gradual increase in temperature can be expected the farther south we go. Between latitude 30° and latitude 27° lies what is known as the Viscaino Desert region, and it is stated that three years have been known to pass without so much as a drop of rain in the lowlands. Below latitude 27° the summer tropical rains obtain. It is unfortunate that paucity of data prevents a detailed survey of the climatic conditions in the peninsula, but those most familiar with this section believe that there can be no connection between the tropical rains of the lower division and the occasional thundershowers of the north.

It might be of interest as bearing out these opinions to quote here from Nelson's exhaustive memoirs cited before. He says in part:

> The first of these [rainy seasons] is part of the tropical summer rainy season which regularly occurs on the west coast of Mexico as far north as northern Sinaloa, the border of which extends across the gulf to Lower California and is specially marked in the southern part of the cape district.

Again:

> The summer rainy season of Lower California * * * begins somewhat later than on the opposite Mexican mainland coast and ends earlier, usually lasting from July to October or November, September being the wettest month.

From 1913 to 1922 there have been 10 outstanding days in July and August when "Sonora storms" were particularly active, viz, July 30, 1914; July 13, 1916; July 27, 1917; July 15, 1919; July 20, 1921; July 18, 1922; July 31, 1922; August 26, 1915; August 24, 1916; and August 23, 1921. The morning weather maps of these dates had many features in common, and the positions of the areas of low and high pressure were in each case relatively the same. In fact, there was such a similarity that a type map was worked out from the barometric and thermometric means of the 10 observations for available stations west of the Rockies. Figure 1 is the result, and to show how closely it corresponds with that of a single day, the map of July 18, 1922 (a date when thunderstorms were general in the mountains of southern California and excessive amounts were reported at several stations), is also exhibited.

It has been found that, while large "thunderheads" might obtain in the district for days at a time, and even scattered showers sometimes fall, heavy and general

rains occurred only under a certain barometric distribution. The semipermanent area of low pressure invariably was charted in the Colorado Valley region, usually with an elongated extension of the isobars northward into the great central valleys of California. Another low area prevailed, as a rule, in British Columbia or Alberta, moving in a southeasterly direction. Between these lay a field of nearly uniform pressure, flanked on either side by a high area, the one impinging on the north Pacific coast, the other overlying the northern Rocky Mountain region and extending southward into New Mexico and western Texas, with the isobars trending northward and southward. Rains, other than purely local showers, in every case under consideration, occurred with a map of these general characteristics.

That the southwestern "thermal" low area is the breeding place of cyclones which detach themselves and move in an easterly direction is generally accepted, but some vital and as yet unsuspected change apparently takes place in the mechanism of the parent LOW before the separation. A definite but obscure relationship seems to exist between this breaking away and widespread "Sonora storms," for within three to five days after uncommon activity is displayed the pressure begins to fall at stations east of the Colorado River, and there is a spreading out of the low area in that direction, which either becomes a separate, well-defined depression or dissipates after a short life. Further, it is almost invariably the case that when this movement begins, a diminution in the force and extent of the "Sonora" takes place, and a fall in temperature in the mountains may be expected. What the connection is between the eastward passage of the one and the prevalency of the other is to be ascertained only after careful study and correlation is made of all available homogeneous phenomena.

To be sure, a pressure distribution such as described would be most favorable for an indraft of moist air into the Colorado Desert region from the Gulf of California to the south, and a marked relation between the "Sonora cloud" and humid weather at desert stations has been suspected. With the prevailing winds from May to October from the south, one of the essential factors in the genesis of thunderstorms is supplied in the damp air from this source. An examination of the records disclosed light, variable winds over the region on these days with all other essentials for strong vertical convection, including an adiabatic temperature gradient in evidence. Even as far west as the coast, pilot-balloon observations (also verified by cirro-cumulus and alto-cumulus movements) show an abnormal prevailing drift from the eastern quadrant above the 2,000-meter level, but below that from the west. Owing to the great number of days with low clouds over the Army and Navy fields where the balloons are released, the results are not highly satisfactory, but it is fairly well established that the "boiling over," as it were, is most pronounced on those days when cumulus and cumulo-nimbus tower above the mountains. After careful observation the writer has yet to observe a single instance of severe "Sonora" conditions when the upper cloud movement was other than from an easterly direction.

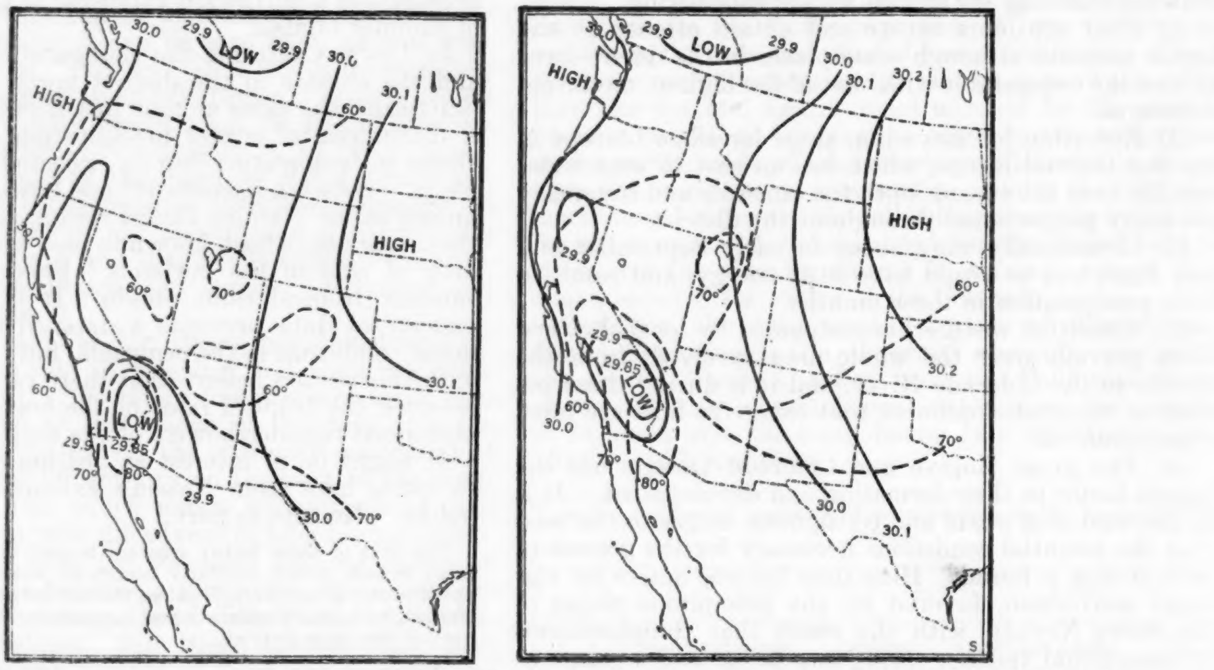

FIG. 1.—Left: Type map for occurrence of Sonora storms. Right: Map for a single day, July 18, 1922, showing agreement between the two.

It is not difficult to believe that over the crests it frequently would happen that much colder air from the Pacific would overrun the warm air spreading out from the east and result in what has been termed a "border storm."[7] As a point in evidence, it is in the valleys with little or no obstruction toward the desert that the excessive rains are most frequent. Northward the topography changes materially, and the ranges and arid wastes are no longer in juxtaposition. If they were, northern and central California would probably experience much the same type of summer thundershowers as in the Sierra Nevada.

In conclusion, Beals[8] has stated that this center of action has not been given the attention or thought it should have received. He has shown that some of the summer rains of the North Pacific States are produced by eddies from the superheated valleys of California. The writer, too, feels that "Sonora storms" can also be traced to the same field of activity, of which but little is known at present, and of which much fruitful investigation can be undertaken.

[7] *Humphreys: Physics of the Air*, p. 323.
[8] MO. WEATHER REV., July, 1922.

THE WORK OF THE WEATHER BUREAU FOR RIVER INTERESTS ALONG THE OHIO RIVER.[1]

By W. C. DEVEREAUX, Meteorologist.

[Weather Bureau, Cincinnati, Ohio.]

At the beginning of the river service by the Weather Bureau in the Ohio Valley the principal object was to forecast the flood stages. At first the flood stages were forecast for the larger cities only, but gradually this service was extended to include all portions of all the rivers in the Ohio Valley. This is a large and very important service and continues to become more and more important as the industries and population of the valley increase, but to-day we are not so much concerned with "much" water as we are with "little" water in the river.

To meet the ever-increasing demands of the river interests, first with the construction of the dams and later with the operation of those completed, there has been developed, or, rather, is being developed (the system is not complete), the greatest and most intense system of low-water river forecasting known in the history of the service. The total drainage area of the Ohio Valley is 210,000 square miles, the Ohio River is nearly 1,000 miles long, and there are several thousand miles of tributaries. Every square mile of surface and every mile of the rivers and streams must be watched in forecasting the changes at the low stages. A flood out of one of the smaller tributaries will have practically no effect on the flood stages in the Ohio River, but a moderate rise in the same tributary will flood a dam in the Ohio below the mouth of the tributary. If this water comes out unexpectedly, it may be an impediment to navigation and may even result in considerable damage; but if its coming is known in advance, even though it may come at night, it may be just the water needed to fill some pool farther down the river.

Aside from the 52 dams completed, under construction, or proposed in the Ohio River, there are more than 90 others in the tributaries, all to supply water for river transportation.

The intelligent operation of these dams requires the greatest possible refinement in forecasting the daily changes in the flow of water. When the dams are down and the river is falling and will continue falling for several days, the lock master at each dam must begin at just the right time to raise the wickets, and he must raise them at just the right rate so as to fill the pool with water, but without causing such a low stage of water below the dam that navigation will be interfered with or stopped. If the river is going to stop falling and begin to rise before a 9-foot stage is reached, the wickets should not be put up, as a sudden rise would flood the dam, in which case the wickets could not be lowered; while, on the other hand, if the river is allowed to fall nearly to the 9-foot stage before the wickets are raised, it is impossible to fill the pool and at the same time to maintain a 9-foot stage below the dam. When the dams are up and the rise is coming down the river, the lock master must be advised of the approach of this rise and the amount of the same. If the rise is small and does not exceed the 12-foot stage, the bear traps are opened or a few of the wickets are lowered to let the rise pass, but if the rise will exceed the 12-foot stage all of the dam must be lowered. If the dam is flooded before all of the wickets are lowered, they stick up in the bottom of the river and form a most serious obstruction to navigation. As the changes at the dams control to a certain extent the stream flow, it is necessary for the forecaster to be advised of these changes before they are made so as to make allowance in his forecasts for the change in the amount of water flowing in the stream. As it often requires a day or more time to raise the wickets at a dam and several hours to lower them, and as these changes should be made when the river stage is between 9 and 12 feet, the river forecasts are of the utmost importance in the effective operation of the dams. At the dams under construction the low-water river forecasts are of great importance.[2]

At the Cincinnati station, we publish the river bulletin as a portion of the weather map. The bulletin is not as complete as we should like to have it, but it is as complete as the space will permit. In addition to the distribution by means of the weather map, the river bulletin is telegraphed to all the other large cities along the river in this district and distributed either by the press or by special bulletins. Similar distribution of the river information is made from the other district centers as Louisville, Parkersburg, Pittsburgh, etc. Every daily newspaper in the cities on the Ohio River should publish the river bulletin and every one in the Ohio Valley should have a weather bulletin.

The weather service and the river service are very closely connected; in fact, they must be worked together. We have had an excellent example of this in the Ohio Valley during the last few days. About 10 days ago a large shipment of coal was brought down from the Kanawha River to Cincinnati on an "artificial wave." This was a fine accomplishment, but due to the unusually dry weather the wave took all of the extra water there was in the river and the result was that many rivermen had boats "hung up" along the river. The weather map for Saturday showed that there had been general rains to the westward of the valley with heavy rains in Oklahoma and floods in the rivers in that and the adjoining States, while in the Ohio River at the same time some of the lowest stages of record were being reported. General rains for the Ohio Valley frequently, and in fact, usually, come from the southwest and to this extent conditions looked favorable for some water for the Ohio River, but we took pains to state on the weather map for that day that the rain area was moving very slowly, and light scattered showers only, if any, would fall in the Ohio Valley during Sunday.

The weather bulletin on the map for Monday morning stated: "The showers in the Ohio Valley (during Sunday) were practically all in that portion of the valley north of the Ohio River, and of no value in raising the water in the Ohio River," but, "there were fair indications Monday morning that general showers would occur in the Ohio Valley during Tuesday or Wednesday." This gave the rivermen time to collect their scattered crews and to "get up steam" ready to start the boats with the first small rise out of the tributaries.

During Monday night the center of a tropical storm moved in from the west Gulf and at observation Tuesday morning this storm was central over northern Louisiana and headed toward the Ohio Valley. The front edge of the rain area had advanced northeastward about 400 miles during the preceding 24 hours and had just reached the southwestern edge of the Ohio Valley. The weather forecast that morning stated that the southwestern rain area would cover the lower Ohio Valley during Tuesday and most of the valley during Wednesday, and the river forecast at the same time was that the Ohio River would continue low during Tuesday night, except in the pools, but would probably begin rising Wednesday. The map for this morning, Wednesday, shows that the rain area has extended eastward as far as Cincinnati and Lexington, Ky., in the middle Ohio Valley.

The bases for all of these forecasts were weather conditions outside of rather than within the Ohio Valley. In an article published a few years ago in the *Proceedings*

[1] An address given at the meeting of the Ohio Valley Improvement Association, Cincinnati, Ohio, Oct. 17, 1923.

[2] Extract from Forecasts of river stages and floods in the Ohio Valley: Their importance to commerce and in conserving life and property, by W. C. Devereaux, in *Proceedings of the Second Pan American Scientific Congress, Section II.*

of the Second Pan-American Scientific Congress it was stated that: "The third step in the development of the river (forecast) service will be reached when the forecaster can calculate the future height of the water for each station in his district as soon as the storm appears on the weather map. As far as known no attempt is being made at the present time to do this, and as the problems are numerous and very complex it possibly will never be attempted, but it is impossible to be sure of what the future may hold." I believe now that we are making considerable progress in that direction.

To do these things and many others not mentioned, to follow the course of storms and rains across the country, follow the water into the streams, and to precede it down the river to the mouth and to mark at each station and at each dam when it will arrive and how high it will be, require specially trained men and a technical and scientific organization. We do not have the divine-given power, as some seem to believe, of reaching up into the sky and pulling down the desired information, but we must solve our problems and do our work in a natural and scientific way.

The river work of the Weather Bureau in the Ohio Valley has grown rapidly during the last few years, but the facilities for doing the work have not been increased in the same proportion. The number of employees in the Cincinnati office is the same as it was 10 years ago, and during that time the river work probably has doubled. We have been able to take on much of this additional work through the splendid cooperation of the United States Engineers and the daily newspapers in this district. We have been urged and even commanded by our superior officers to economize and to use efficient business methods, and we have complied to the best of our ability. Both of these terms are rather elastic and like all elastic objects can be stretched only to a certain limit. We have stretched the river service to the limit with the funds available and it does not cover the work as it should be covered. There is not a station on the Kentucky River. We do not receive a telegraphic report of a river stage or of the amount of rainfall from a single station in that large and important valley. The rainfall areas over the Kentucky Valley move directly over the Licking and then the Big Sandy and the Kanawha Valleys, and the waters from all of those rivers reach the Ohio at vital spots. As stated in the last report of the Chief of the Weather Bureau, "More river-gaging stations and much more intensive measurement of precipitation are needed. These things can be accomplished with a very reasonable increase in appropriations, and it is hoped that funds will soon be available. As it is, the service is virtually at a standstill so far as field extensions are concerned. One vital need is that of an engineer who can serve as a field man, inspecting stations, making repairs to equipment, making surveys for the establishment of permanent bench marks and other measurements of precision. These surveys are of highest importance."

NOTES, ABSTRACTS, AND REVIEWS.

A CORRECTION.

An abstract entitled "The size of meteors" written upon the recent work of Lindeman and Dodson was reprinted in the MONTHLY WEATHER REVIEW for June, 1923, page 316. The authors have stated to the editor that their view as expressed in the closing paragraph of the above-named abstract is better represented by the following: "Our view is that the short-wave radiation from the sun must give rise to the formation of ozone, and while this will never be found in more than a small pro portion, it may greatly modify the radiative equilibrium. Thus, it is known that all the sun's radiation of shorter wave length than 3,000 Å is absorbed in the upper air and will raise the temperature at those heights considerably. The earth's radiation will only be absorbed by ozone over a small range of wave length, about 9.5 μ, and the temperature can never be raised above approximately the temperature of the stratosphere by this cause."

CENTRAL METEOROLOGICAL OBSERVATORY AT TOKYO BURNED.

American friends of Japanese meteorologists will be interested in a recent letter from Dr. S. Fujiwhara, of the Central Meteorological Observatory at Tokyo. Doctor Fujiwhara reports that in the great fire which followed the recent severely destructive earthquake in Japan the main building of the Central Observatory was destroyed. Many instruments and books were lost, and the official residences of the staff were burned. Fortunately, the Tokyo meteorological records covering a period of 40 years were saved.

Doctor Fujiwhara reports the interesting fact that hourly observations were continued throughout the fire, and that at midnight, when the main building was burned, the temperature in a shelter about 200 feet distant rose to 46.4° C. (115° F.). This effort to keep a continuous record in spite of the great difficulties under which the observers were working evidently is characteristic of the efforts that are being made to restore normal conditions as rapidly as possible.—*C. L. M.*

GREAT BRITISH DROUGHTS.

Mr. Chas. Harding in *Nature*, July 14, 1921, discusses briefly the record of droughts in Great Britain in connection with the one which has prevailed since October, 1920. Since that time the rainfall at Greenwich Observatory has been but 9.78 inches, or 56 per cent of the normal. The controlling factors of the weather associated with drought in Great Britain have been a low barometer to the north of the British Isles and a relatively higher barometer with anticyclonic conditions in the south of England; in other words, an extension of the Azores HIGH toward and over southern England and the Channel.

Mr. Harding's definition of absolute and partial drought is particularly interesting. The writer of this note, in compiling the statistics of drought published in Bulletin Q-Climatology of the United States, adopted the following as applicable to the United States east of the 100th meridian. A drought was considered to have existed whenever the rainfall for 21 days or longer amounted to 30 per cent less of the seasonal normal.

Mr. Harding defines absolute drought as a period of more than 14 days without rain, and partial drought as a period of more than 28 days the aggregate rainfall of which does not exceed 0.01 inch per diem.—*A. J. H.*

MOISTURE RELATIONS OF PEACH BUDS DURING WINTER AND SPRING.

By EARL S. JOHNSTON.

[Author's abstract.]

The moisture index is a term applied to the quotient obtained by dividing the moisture content of peach fruit buds by their dry weight. It is thus the ratio of moisture content to dry weight, or the amount of moisture per unit of dry matter.

The moisture indices of three peach varities studied in the year 1921–22 show low winter values with increasingly high spring values. These values throughout most of the winter and spring are highest for the Late Crawford, lowest for the Greensboro, and intermediate for the Elberta variety. This index seems to be correlated with bud hardiness in these three varities; the higher the index the less hardy the variety.

An apparent correlation was indicated between the moisture index in spring and the temperature of incipient ice formation within the buds when artificially cooled in the laboratory.

Fruit buds were found to depend directly on the roots of the trees for their moisture in early autumn, while in midwinter water in the tree served as an adequate source.

The rate of increase in the moisture index after January 1 was found to vary on five different years as the sum of the effective daily mean temperatures above 43° F. Although the factor of proportionality is a constant for any one year, it may vary for different years. Certain conditioning influences, such as the amount and distribution of rainfall, that are operative during or preceding dormancy apparently "predetermine" the exact relationship between air temperature and the moisture index of the buds for the period following dormancy.

The relation between the moisture index and the effective temperatures is expressed as a straight line equation, $y=a+bx$. The constant a is of little significance, but seems to be related to rainfall during dormancy. The constant b varies with the variety and at the same time seems to reflect rainfall conditions during the preceding June, July, August, and September.

THE MARINE OBSERVER.

Under the above title the British Meteorological Office has recently issued the first number of a magazine devoted to marine meteorology and published especially in the interests of the observers who cooperate with that office by furnishing meteorological and hydrographical observations made at sea.

The functions of the new publication are described as follows: "To provide information useful to navigation concerning winds, weather, climate, currents, derelicts, and ice; to stimulate interest in observation and the practice of meteorology at sea; to promote the use of wireless weather reporting for shipping; to provide a means whereby mariners may give their experience to others; and to foster the traditions of marine meteorology upon international lines." The new publication will in a measure take the place of the well and favorably known British Monthly Meteorological Charts, the periodical publication of which has been discontinued. Hereafter these charts will be used only to portray the more or less permanent meteorological and hydrographical features of the oceans.

In a "foreword" by Dr. G. C. Simpson, director of the Meteorological Office, credit is given to Capt. L. A. Brooke Smith, marine superintendent, for suggesting the idea of the magazine and carrying the project into effect. Doctor Simpson pays a graceful and well-merited tribute to the corps of marine observers who have contributed so much to the general knowledge of meteorological science.

There is a wealth of material in the initial number and the typographical appearance is pleasing. Altogether the new venture is one that is sure to meet with the hearty approval of all those interested in marine meteorology.—*F. G. T.*

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Meteorologia conscripta . . . Additæ sunt tabellæ quæ totam meteororum doctrinam complectuntur. . . . Witebergæ. 1568. 468 p. 16½ cm.

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C. F. TALMAN, Meteorologist in Charge of Library.

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SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING NOVEMBER, 1923.

By HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations.

For a description of instruments and exposures, and on account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, **48**:225, and a note in the REVIEW for November, 1922, **50**:595.

From Table 1 it is seen that solar-radiation intensities averaged slightly below normal values for November at Washington, D. C., and Lincoln, Nebr., and slightly above normal at Madison, Wis.

Table 2 shows a slight deficiency in the total radiation received on a horizontal surface at Washington and Madison, and a slight excess at Lincoln.

Skylight-polarization measurements obtained at Washington on 10 days give a mean of 60 per cent, with a maximum of 70 per cent on the 9th. These are slightly above average values for November at Washington. At Madison no measurements were obtained on account of the generally cloudy condition of the sky.

TABLE 1.—*Solar radiation intensities during November, 1923.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance: 8 a.m. / 75th mer. time. / e.	78.7° / A. M. Airmass 5.0	75.7° / 4.0	70.7° / 3.0	60.0° / 2.0	0.0° / [1] 1.0	60.0° / P. M. 2.0	70.7° / 3.0	75.7° / 4.0	78.8° / 5.0	Noon. / Local mean solar time. / e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Nov. 1	3.81	0.53	0.69	0.93	1.10	......	1.25	1.05	0.98	0.88	4.95
2	3.63	......	......	0.64	......	......	......	......	......	......	5.36
3	4.57	0.77	0.89	1.03	1.03	......	1.15	1.01	0.87	0.78	4.75
9	2.74	......	......	......	......	......	1.31	1.14	0.95	0.86	2.36
10	3.63	0.52	0.63	0.78	1.04	......	1.12	0.96	0.83	0.73	3.45
13	5.16	0.54	0.66	0.80	0.97	......	......	......	......	......	6.02
14	4.95	......	......	......	1.25	......	1.14	1.03	0.82	0.75	5.16
19	4.17	0.92	1.07	1.19	1.36	1.59	1.35	1.09	0.92	0.78	3.30
20	3.45	0.49	0.61	0.73	1.00	......	1.06	0.83	0.65	0.52	3.63
21	5.79	......	......	0.73	......	......	......	......	......	......	8.18
24	6.76	......	......	......	......	......	1.21	......	......	......	4.75
Means	......	0.63	0.76	0.85	1.11	......	1.20	1.02	0.86	0.76	......
Departures	......	−0.11	−0.08	−0.15	−0.07	......	+0.03	+0.04	+0.04	+0.03	......

TABLE 1.—*Solar radiation intensities during November, 1923*—Con.

[Gram-calories per minute per square centimeter of normal surface.]

Madison, Wis.

Date.	Sun's zenith distance: 8 a.m. / 75th mer. time. / e.	78.7° / A. M. Airmass 5.0	75.7° / 4.0	70.7° / 3.0	60.0° / 2.0	0.0° / [1] 1.0	60.0° / P. M. 2.0	70.7° / 3.0	75.7° / 4.0	78.8° / 5.0	Noon. / Local mean solar time. / e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Nov. 6	3.15	......	......	......	......	......	......	1.18	......	......	4.95
8	2.49	......	......	......	......	......	......	1.21	......	......	2.87
9	3.00	0.91	1.01	1.14	1.23	......	......	1.11	......	......	3.63
19	3.81	1.03	1.14	1.26	......	......	......	......	......	......	4.17
Means	......	(0.97)	(1.08)	(1.24)	(1.23)	......	......	1.17	......	......	......
Departures	......	+0.10	+0.06	+0.04	−0.06	......	......	+0.00	......	......	......

Lincoln, Nebr.

Date.	8 a.m. / e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	Noon. / e.
Nov. 5	3.30	1.05	1.17	1.29	1.42	1.59	1.41	1.22	1.09	1.04	3.00
6	2.87	0.80	0.90	1.04	1.19	......	......	......	......	......	4.57
7	4.17	......	......	......	......	......	1.34	......	......	0.81	3.81
8	3.81	......	......	1.07	1.27	......	1.29	1.05	0.93	0.84	3.99
9	3.15	......	......	1.09	1.30	......	......	......	......	......	5.16
14	4.57	......	......	......	......	......	1.26	......	......	......	5.36
15	4.95	......	......	1.15	1.33	1.53	1.37	1.23	......	0.99	5.56
17	4.17	0.69	0.77	1.04	1.34	......	......	......	......	......	4.75
19	3.63	......	......	......	......	......	1.36	1.19	1.07	0.98	4.75
22	2.74	0.82	0.95	......	......	......	......	......	......	......	3.63
23	4.17	......	1.14	1.28	1.43	1.60	......	......	......	......	4.37
26	2.74	......	1.20	1.31	1.46	......	......	......	......	......	2.06
28	2.62	......	1.03	1.16	......	......	......	1.15	0.98	0.89	3.30
Means	......	0.84	1.02	1.16	1.34	......	1.34	1.17	1.02	0.92	......
Departures	......	−0.10	−0.03	−0.04	−0.02	......	−0.03	−0.03	−0.03	−0.02	......

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning—	Average daily radiation.				Average daily departure for the week.			Excess or deficiency since first of year.		
	Chicago.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Nov. 5	161	161	219	291	−66	+51	+63	−4,837	−795	−2,421
12	114	169	105	228	−36	−44	+14	−5,091	−1,103	−2,322
19	114	197	131	207	+12	−5	+5	−5,008	−1,138	−2,289
26	58	166	82	206	−3	−44	+15	−5,030	−1,446	−2,181

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month varied considerably, as compared with the normal, as shown by the departures at a number of selected land stations on the coast and islands of the North Atlantic.

The barometric readings are in inches, for 8 a. m. 75th meridian time, and the departures are approximate, as the normals were taken from the Pilot Chart and are based on Greenwich mean noon observations, corresponding to 7 a. m. 75th meridian time.

St. Johns, Newfoundland, mean 30.08 inches, departure, +0.04 inches; Nantucket, 30.06, −0.03; Hatteras, 30.07, −0.07; Key West, 30.05, +0.02; New Orleans, 30.13, +0.02; Swan Island, 29.91, −0.01; Turks Island, 30.03, +0.03; Bermuda, 29.98; −0.16; Horta, Azores, 30.19, +0.08; Lerwick, Shetland Islands, 29.57, −0.13; Valencia, Ireland, 29.86, −0.04; London, 29.78, −0.16.

The number of days on which winds of gale force were reported did not differ materially from the normal over the greater part of the ocean, although in the 5-degree square between the 40th and 45th parallels and the 55th and 60th meridians, where the maximum occurred, gales were observed on 8 days, which is considerably in excess of the percentage shown on the Pilot Chart. The number of disturbances in southern waters was also somewhat greater than usual.

According to reports received, fog was observed on 11 days in the vicinity of the Grand Banks, which is not far from the normal; it was reported on from 4 to 6 days over the middle section of the northern steamer

Hering, J. H.
Bespiegeling over Neêrlandsch waternood, tusschen den 14den en 15den Nov: MDCCLXXV. 2 v. Amsterdam. 1776. v. 1–2. plates (fold.) 23 cm.

Hernandez, Jesus.
Temperature of Mexico. Washington. 1923. iii, 24 p. diagr. charts. 31 cm. (Mon. wea. rev., suppl. no. 23.)

Humphreys, William J.
Weather proverbs and paradoxes. Baltimore. 1923. viii, 125 p. plates. diagr. 19½ cm.

Kenya. [B. E. A.] **Dept. of agriculture,** *comp.*
REAAA map of rainfall distribution in East Africa . . . produced by the Royal East African automobile association. n.p. 1923. 1 map. 47x56 cm.

Leutmann, Joh. G.
Instrumenta meteorognosiæ inservientia . . . Wittenbergæ. 1725. 175+ p. 17 cm.

Martinelli, Giuseppe, *comp.*
Notizie sui terremoti osservati in Italia durante l'anno 1911. Roma. 1923. 586 p. 24 cm. (Boll. soc. sism. Ital. Appendice v. 18, 1914.)

Mengel, Octave.
Caractère climatique de Font-Romeu et de Mont-Louis, tiré des conditions générales de la circulation de l'atmosphère dans les Pyrénées-Orientales. Paris. 1923. 16 p. illus. plate. 31½ cm. (Memorial de l'Office nat. mét. de France. lre annee. no. 5.)

Neri, Giovanni de.
Trattato della mutatione dell'aria secondo gl'orti, & occasi d'alcune stelle fisse, & pronostici universali, di quello che significano il nascimento, & cadimento delle sudette stelle . . . Verona. 1600. 48 p. 21 cm.

Panarolo, Domenico.
Aërologia cioè discorso dell'aria, trattato utile per la sanità. Roma. 1642. 91 p. 16½ cm.

Placentinus, Jacobus.
De barometro dissertationes. Patavii. 1711. vi, 150 p. plates. 15 cm.

Ramazzini, Bernardo.
Ephemerides barometricæ mutinenses anni MDCXCIV. Unà cum disquisitione causæ ascensus, ac descensus mercurii in Torricellianâ fistulâ iuxta diversum aeris statum. Mutinæ. 1695. 127 p. 15½ cm.

Rauch, F. A.
Harmonie hydro-végétale et météorologique, ou recherches sur les moyens de recréer avec nos forêts la force des temperatures et la régularité des saisons, par des plantations raisonnées . . . 2 v. Paris. n.d. v. 1–2. plates. 20 cm.

Romas, de.
Mémoire, sur les moyens de se garantir de la foudre dans les maisons; suivi d'une lettre sur l'invention du cerf-volant électrique, avec les piéces justificatives de cette même lettre. Bordeaux. 1776. xxiv, 156 p. plates. 17 cm.

Rudovic, L.
O kolebaniiakh urovnia Baltiiskago moria. Petrograd. 1917. 204 p. diagr. plates (fold.) [Author, title, and text in Russian.] [On the variation of the level of the Baltic sea.]

Th[ouvenel,] P[ierre.]
Mélanges d'historire naturelle, de physique et de chimie. Mémoires sur l'aérologie et l'électrologie: ouvrage divisé en deux parties: la première servant de complément au traité sur le climat d'Italie: la seconde devant servir d'introduction au traité sur la minéralogie des Alpes et de l'Apennin. 3 v. Paris. 1806. v. 1–3. plates. 21½ cm.

Toaldo, Giuseppe.
Completa raccolta di opuscoli, osservazioni, e notizie diverse contenute nei giornali astrometeorologici dall' anno 1773 sino all' anno 1798. 4 v. Venezia. 1802–1803. v. 1–4. 23 cm.

Trappes. (France.) Observ. aérodynamique.
Lancer de ballon-sonde. no. 1–12. Le 15 mai–le 28 oct. 1922. [Paris.] 1922. unp. diagr. maps. 31 cm.

Zückerts, D. Johann F.
Abhandlung von der Luft und Witterung und der davon abhangenden Gesundheit der Menschen. Berlin. 1770. 215 p. 18 cm.

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. F. TALMAN, Meteorologist in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Cambridge philosophical society. Transactions. v. 21. pt. 6. 1923.
Chapman, S. The motion of a neutral ionised stream in the earth's magnetic field. p. 577–594.

Hemel en dampkring. Den Haag. 21e jaargang. November, 1923.
Dijk, G. van. Planeten en aardbevingen. p. 345–349.
Hartman, Ch. M. A. De zomer van 1923. p. 343–344.

Nature. Paris. 51 année. 17 novembre 1923.
Debeaupuis, M. Le tremblement de terre du Japon. p. 310–313.

Reale accademia dei Lincei. Atti. Roma. (5) Rendiconti. v. 32.
Eredia, Filippo. Sui terremoti di Porto Civitanova (Macerata). p. 215–219.
Palazzo, L. L'equazione Cancani (Köveslígethy) e la determinazione delle profondità ipocentrali. p. 224–227.
Palazzo, L. Sull terremoto dalmato del 15 marzo 1923. p. 219–224.

Revue générale des sciences. Paris. 34 année. 30 septembre 1923.
Montessus de Ballore, F[ernand] de. p. 489. [Obituary.]

Royal society of London. Proceedings. London. Series A. v. 104. September, 1923.
Dobson, G. M. B. Measurements of the sun's ultra-violet radiation and its absorption in the earth's atmosphere. p. 252–271.

Science. New York. v. 58. 1923.
Livingston, Burton E. Blackened spheres for atmometry. p. 182–183. (Sept. 7.)
Goto, Seitaro. The Japanese earthquake. p. 492–493. (Dec. 14.)

Science progress. London. v. 18. October, 1923.
Andrews, J. P. The propagation of sounds from explosions. p. 292–293.
Davison, Charles. Inaudible air-waves. p. 294–297.

Sociedad astronómica de España y América. Revista. Barcelona. Año 13. Julio-agosto 1923.
Selga, Miguel. Duración de los temporales a bordo. p. 52–57.
Solá, José Comas. El terremoto del 10 de julio. p. 51–52.

Tycos-Rochester. Rochester, N. Y. v. 13. October, 1923.
Brooks, Charles F. Unreal "errors" of thermometers. p. 6. How storms march. p. 19–20; 21. [Abstr. of art. by W. S. Belden.]
Is world entering fifth glacial age? p. 28–31.
Meisinger, C. LeRoy. Notes on the early history of barometry. p. 11–13.
Palmer, A. H. Keep a weather record. p. 37.
Palmer, A. H. Popular misconceptions concerning the weather. p. 17–18.
Palmer, A. H. Weather insurance. p. 21–23.
Parsons, Floyd W. Humidity and health. More moisture in the air we breathe will save money on fuel and doctor's bills. p. 26–27. [Repr. Phila. Ledger.]
Scarr, James H. The truth about the weather. p. 8–10. [Repr. Pop. sc. mo.]
Yates, Raymond Francis. The human body as a thermostat. p. 24–25.

SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING NOVEMBER, 1923.

By HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations.

For a description of instruments and exposures, and on account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, **48**:225, and a note in the REVIEW for November, 1922, **50**:595.

From Table 1 it is seen that solar-radiation intensities averaged slightly below normal values for November at Washington, D. C., and Lincoln, Nebr., and slightly above normal at Madison, Wis.

Table 2 shows a slight deficiency in the total radiation received on a horizontal surface at Washington and Madison, and a slight excess at Lincoln.

Skylight-polarization measurements obtained at Washington on 10 days give a mean of 60 per cent, with a maximum of 70 per cent on the 9th. These are slightly above average values for November at Washington. At Madison no measurements were obtained on account of the generally cloudy condition of the sky.

TABLE 1.—*Solar radiation intensities during November, 1923.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.8°	Noon.
	75th mer. time.	Airmass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Nov. 1	3.81	0.53	0.69	0.93	1.10	......	1.25	1.05	0.98	0.88	4.95
2	3.63	......	......	0.64	......	......	......	......	......	......	5.36
3	4.57	0.77	0.89	1.03	1.03	......	1.15	1.01	0.87	0.78	4.75
9	2.74	......	......	......	......	......	1.31	1.14	0.95	0.86	2.36
10	3.63	0.52	0.63	0.78	1.04	......	1.12	0.96	0.83	0.73	3.45
13	5.16	0.54	0.66	0.80	0.97	......	......	......	......	......	6.02
14	4.95	......	......	......	1.25	......	1.14	1.03	0.82	0.75	5.16
19	4.17	0.92	1.07	1.19	1.36	1.59	1.35	1.09	0.92	0.78	3.30
20	3.45	0.49	0.61	0.73	1.00	......	1.06	0.83	0.65	0.52	3.63
21	5.79	......	......	0.73	......	......	......	......	......	......	8.18
24	6.76	......	......	......	......	......	1.21	......	......	......	4.75
Means	......	**0.63**	**0.76**	**0.85**	**1.11**	......	**1.20**	**1.02**	**0.86**	**0.76**	......
Departures	......	**−0.11**	**−0.08**	**−0.15**	**−0.07**	......	**+0.03**	**+0.04**	**+0.04**	**+0.03**	......

TABLE 1.—*Solar radiation intensities during November, 1923*—Con.

[Gram-calories per minute per square centimeter of normal surface.]

Madison, Wis.

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.8°	Noon.
	75th mer. time.	Airmass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Nov. 6	3.15	......	......	......	......	......	......	1.18	......	......	4.95
8	2.49	......	......	......	......	......	......	1.21	......	......	2.87
9	3.00	0.91	1.01	1.14	1.23	......	......	1.11	......	......	3.63
19	3.81	1.03	1.14	1.26	......	......	......	......	......	......	4.17
Means	......	**(0.97)**	**(1.08)**	**(1.24)**	**(1.23)**	......	......	**1.17**	......	......	......
Departures	......	**+0.10**	**+0.06**	**+0.04**	**−0.06**	......	......	**+0.00**	......	......	......

Lincoln, Nebr.

Nov. 5	3.30	1.05	1.17	1.29	1.42	1.59	1.41	1.22	1.09	1.04	3.00
6	2.87	0.80	0.90	1.04	1.19	......	......	......	......	......	4.57
7	4.17	......	......	......	......	......	1.34	......	......	0.81	3.81
8	3.81	......	......	1.07	1.27	......	1.29	1.05	0.93	0.84	3.99
9	3.15	......	......	1.09	1.30	......	......	......	......	......	5.16
14	4.57	......	......	......	......	......	1.26	......	......	......	5.36
15	4.95	......	......	1.15	1.33	1.53	1.37	1.23	......	0.99	5.56
17	4.17	0.69	0.77	1.04	1.34	......	......	......	......	......	4.75
19	3.63	......	......	......	......	......	1.36	1.19	1.07	0.98	4.75
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23	4.17	......	1.14	1.28	1.43	1.60	......	......	......	......	4.37
26	2.74	......	1.20	1.31	1.46	......	......	......	......	......	2.06
28	2.62	......	1.03	1.16	......	......	......	1.15	0.98	0.89	3.30
Means	......	**0.84**	**1.02**	**1.16**	**1.34**	......	**1.34**	**1.17**	**1.02**	**0.92**	......
Departures	......	**−0.10**	**−0.03**	**−0.04**	**−0.02**	......	**−0.03**	**−0.03**	**−0.03**	**−0.02**	......

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning—	Average daily radiation.				Average daily departure for the week.			Excess or deficiency since first of year.		
	Chicago.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Nov. 5	161	161	219	291	−66	+51	+63	−4,837	−795	−2,421
12	114	169	105	228	−36	−44	+14	−5,091	−1,103	−2,322
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St. Johns, Newfoundland, mean 30.08 inches, departure, +0.04 inches; Nantucket, 30.06, −0.03; Hatteras, 30.07, −0.07; Key West, 30.05, +0.02; New Orleans, 30.13, +0.02; Swan Island, 29.91, −0.01; Turks Island, 30.03, +0.03; Bermuda, 29.98; −0.16; Horta, Azores, 30.19, +0.08; Lerwick, Shetland Islands, 29.57, −0.13; Valencia, Ireland, 29.86, −0.04; London, 29.78, −0.16.

The number of days on which winds of gale force were reported did not differ materially from the normal over the greater part of the ocean, although in the 5-degree square between the 40th and 45th parallels and the 55th and 60th meridians, where the maximum occurred, gales were observed on 8 days, which is considerably in excess of the percentage shown on the Pilot Chart. The number of disturbances in southern waters was also somewhat greater than usual.

According to reports received, fog was observed on 11 days in the vicinity of the Grand Banks, which is not far from the normal; it was reported on from 4 to 6 days over the middle section of the northern steamer

lanes, on from 2 to 4 days off the American coast, north of the 35th parallel, and was apparently rare off the coast of Europe.

From the 1st to 4th an area of high pressure was over New England and New York, and during that period moderate to strong northeasterly gales, with little shift of wind until near the end, were reported by a number of vessels in the region between the 25th and 40th parallels, west of the 60th meridian. This disturbance was a true "norther," due to the steep pressure gradient between the north and south, as in the Caribbean Sea the barometric readings were somewhat below normal. The weather map for the morning of November 2 shows that at New York and Portland, Me., the barometer read 30.62 inches and at Swan Island and Kingston, Jamaica, 29.90 inches. Storm logs:

American S. S. *Esparta:*

Gale began on the 1st, wind NE. Lowest barometer 30.13 inches at noon on the 1st, wind NE., 8, in latitude 33° 43′ N., longitude 76° 30′ W. End on the 3d, wind NE. Highest force of wind 8, NE.; steady NE.

American S. S. *Mobile City:*

Gale began on the 1st, wind NE. Lowest barometer 30.05 inches at 3 p. m. on the 1st, wind NE., 4, in latitude 26° 41′ N., longitude 79° 54′ W. End on the 2d, wind variable. Highest force of wind 8, NE.; shift 4 points. At time of lowest barometer wind shifted from N. to NE., and increased in force from 2 to 5, then gradually getting stronger until a force of 8 was reached. Meanwhile the barometer rose from 30.05 to 30.23 inches where it stopped until gale died out at 6 p. m. on the 2d.

On the 2d a LOW appeared near latitude 55° N., longitude 25° W.; this moved rapidly eastward, accompanied by rain and hail, and on the 3d was central off the north coast of Scotland, reaching the North Sea on the 4th. The storm area was at its maximum on the 3d when it extended as far west as the 30th Meridian. Storm logs:

Dutch S. S. *American:*

Gale began on the 2d, wind WNW. Lowest barometer 29.50 inches at 2 p. m. on the 2d, wind NW., in latitude 55° 50′ N., longitude 26° 41′ W. End on the 3d, wind NW. Highest force of wind 10; shifts WNW.-NW.

British S. S. *Canadian Leader:*

Gale began on the 3d, wind SW. Lowest barometer 29.75 inches at 8 a. m. on the 3d, wind SW., 9, in latitude 51° 37′ N., longitude 3° 57′ W. End on the 4th, wind WNW. Highest force of wind 9; shifts 5 points.

On the 4th there was a moderate depression over the northern part of the Gulf of Mexico that moved northeastward, and on the 8th was over the Province of Quebec. The weather conditions along the American coast during the progress of this LOW were not as a rule severe, although a few vessels west of the 65th meridian encountered moderate gales, as shown by following storm logs:

British S. S. *Tuscarora:*

Gale began on the 5th, wind N. Lowest barometer 29.83 inches at midnight on the 5th, wind N., 7, in latitude 37° 35′ N., longitude 66° 40′ W. End at 4 a. m. on the 6th, wind NE. Highest force of wind 8; shifts N-NNE-NE.

British S. S. *Maravi:*

Gale began on the 7th, wind W., 7. Lowest barometer 30.13 inches at 4 p. m. on the 7th, wind W., 7, in latitude 34° 10′ N., longitude 71° 45′ W. End on the 8th, wind W., 6. Highest force of wind 8, W.; no shifts, very high westerly sea.

On the 6th and 7th there was an area of high pressure over the northwestern part of the Gulf of Mexico, and on the former date vessels a short distance south of Brownsville, Tex., experienced a severe "norther" as shown by following storm log.

Honduran S. S. *Yoro:*

Gale began on the 6th, wind NNW. Lowest barometer 30.11 inches at 2 a. m. on the 6th, wind NW., 8, in latitude 20° 10′ N., longitude 95° 28′ W. End on the 7th, wind NW. Highest force of wind, 8; shifts NNW-NW.

From the 6th to 9th low pressure prevailed over the British Isles, and during that period vessels east of the 30th meridian encountered northerly to northwesterly gales. Storm log:

British S. S. *Verentia:*

Gale began on the 7th, wind NW. Lowest barometer 29.98 inches at 4 p. m. on the 7th, wind NNW., in latitude 49° 58′ N., longitude 18° W. End on the 8th, wind NW. Highest force of wind 8, NW.; shifts NW-W-NNW.

On the 10th there was an area of low pressure in the vicinity of Bermuda; this drifted slowly northeastward and from the date of its first appearance until the 15th moderate to strong gales prevailed over part of the western section of the ocean, the storm area expanding and contracting from day to day. Storm logs:

American S. S. *Commack:*

Gale began on the 10th, wind variable. Lowest barometer 29.78 inches at 5 p. m. on the 10th, wind NW., 8, in latitude 31° 28′ N., longitude 65° 42′ W. End on the 11th, wind NW., 8; shifts not given.

French S. S. *Leopold L. D.:*

Gale began on the 12th, wind NE. Lowest barometer 29.91 inches at noon on the 13th, wind NE., 9, in latitude 41° 45′ N., longitude 63° W. End on the 13th, wind NE. Highest force of wind 10; steady NE.

American S. S. *Eastside:*

Gale began on the 14th, wind E., 8. Lowest barometer 29.61 inches at 4 p. m. on the 14th, wind W., 5, in latitude 42° 22′ N., longitude 53° 56′ W. End on the 15th, wind NNE. Highest force of wind 10, ENE., shifts W-E-NE.

On the 10th and 11th moderate to strong northerly gales occurred off the coast of southern Europe, although the storm area appeared to be of limited extent. Storm log:

British S. S. *Saxoleine:*

Gale began on the 9th, wind N. Lowest barometer 29.78 inches at 8 a. m. on the 10th, wind N., 10, in latitude 44° 46′ N., longitude 12° 24′ W. End on the 12th, wind NE. Highest force of wind 10, NE.; shifts N-NE.

From the 12th to 17th low pressure prevailed in northern European waters, attended by heavy weather over the eastern section of the steamer lanes. Storm logs:

American S. S. *Eastern Leader:*

Gale began on the 12th, wind WNW. Lowest barometer 28.97 inches on the 14th, wind N., 2, in latitude 56° 20′ N., longitude 24° 08′ W. End on the 14th, wind NW. Highest force of wind 9; shifts not given.

British S. S. *Boston City:*

Gale began on the 12th, wind W. Lowest barometer 29.15 inches at 8 p. m. on the 14th, wind WNW., in latitude 50° 45′ N., longitude 22° 45′ W. End on the 16th, wind WNW. Highest force of wind 10, WNW.; shifts SW-W-WNW.

British S. S. *Baltic:*

Gale began on the 16th, wind W. Lowest barometer 29.94 inches at noon on the 16th, wind WNW., 8, in latitude 49° 43′ N., longitude 27° 26′ W. End on the 17th, wind WNW. Highest force of wind 9, WNW.; steady WNW.

On the 14th a moderate depression appeared near latitude 30° N., longitude 70° W.; it moved slowly northeastward and on the 15th was central a short distance east of Bermuda where a barometric reading of 29.56 inches was recorded. This disturbance was apparently

not especially severe in character, as the following was the only storm log received.

American S. S. *West Norranus:*

Gale began on the 14th, wind WSW. Lowest barometer 29.80 inches at 4 p. m. on the 14th, wind NW., in latitude 27° 57′ N., longitude 71° 35′ W. End on the 14th, wind NW. Highest force of wind 7; shifts WSW–NW.

On the 17th and 18th there was another disturbance near the Bermudas, and vessels to the westward of these islands encountered northerly to northwesterly gales, as shown by following storm log:

British S. S. *Matura:*

Gale began on the 17th, wind SSW. Lowest barometer 29.66 inches at 3:10 p. m. on the 17th, wind SSW., 9, in latitude 32° 43′ N., longitude 70° W. End on the 18th, wind NNW. Highest force of wind 9; shifts SW–W. At 3 p. m. on the 17th we experienced a terrific squall from the SSW. with thunder, lightning, rain and hail following a regular deluge of rain, lasting altogether about 7 minutes. The hail unusually large, each ball being about ¼ inch in diameter. The wind backed from NW. to SSW. and every indication of bad weather. The first violent squall was followed by others of less force, with lulls between, and from 4:30 p. m. it set in to blow steadily, force 8, until about 2:30 a. m. on the 18th. The wind then shifted to WSW., the barometer rising gradually and the wind moderating.

On the 18th and 19th a deep depression surrounded Newfoundland, although no reports were received indicating unusually heavy winds.

On the 20th moderate northerly gales were reported off the coast of northern Europe, but no storm logs were received from vessels in that locality.

On the 21st and 22d there was a disturbance central near latitude 50° N., longitude 35° W., and on the latter date the storm area extended as far south as the 35th parallel. Storm logs:

German S. S. *Bayern:*

Gale began on the 21st, wind WNW., 7. Lowest barometer 29.62 inches at 3 p. m. on the 22d, wind NNW., 10, in latitude 46° 41′ N., longitude 38° 36′ W. End on the 22d, wind ENE. Highest force of wind 10, NNW.; shifts 4 points to east.

British S. S. *Adra:*

Gale began on the 22d, wind SSE. Lowest barometer 30.00 inches at 9:12 a. m. on the 23d, wind NNW., 9, in latitude 36° 09′ N., longitude 41° 44′ W. End on the 23d, wind NE. Highest force of wind 10, WNW.; shifts NNW–N.

Charts VIII to XI show the conditions from the 23d to 26th, inclusive, when unusual weather existed in the vicinity of the Azores, and heavy winds also prevailed over different sections of the ocean. Storm logs:

French S. S. *Britannia:*

Gale began on the 24th, wind NE. Lowest barometer 29.74 inches, wind NE. 7, at the Azores. End on the 26th, wind NNE. Highest force of wind 9; steady SE.

Dutch S. S. *Prins der Nederlanden:*

Gale began on the 24th, wind W. Lowest barometer 29.78 inches at 4 a. m. on the 25th, wind WSW., in latitude 32° 10′ N., longitude 74° 15′ W. End on the 25th, wind NW. Highest force of wind 8; shifts WSW–W–WNW–NW.

American S. S. *Maiden Creek:*

Gale began on the 24th, wind SE. Lowest barometer 29.93 inches on the 24th, wind SE., 8, in latitude 41° 45′ N., longitude 56° 50′ W. End on the 26th, wind SSE. Highest force of wind 9; steady SE.

On the 27th gales still prevailed over a limited area between the 40th and 50th parallels and the 20th and 35th meridians. Moderate weather was the rule over the remainder of the ocean, with the exception that one vessel near latitude 42° N., longitude 56° W., and another near latitude 34° N., longitude 50° W., reported southeasterly winds, force 8, although neither rendered storm logs. By the 28th the storm area over the eastern section of the ocean had contracted materially, while heavy winds were encountered over a limited area in southern waters. Storm log:

American S. S. *Gaffney:*

Gale began on the 27th, wind SE. Lowest barometer 30.13, wind S., 7, in latitude 34° 10′ N., longitude 50° 20′ W. End on the 28th, wind S. Highest force of wind 8, SSE.; shifts 4 points.

The 29th and 30th were apparently the quietest days of the month, as practically all the reports received indicated moderate weather.

CYCLONIC DISTURBANCES IN THE SOUTH ATLANTIC OCEAN.

By ALBERT J. MCCURDY, Jr.

Gales of short duration and limited extent prevailed off the Brazilian coast in the first and middle decades of November, as indicated by weather reports received from vessels traversing the southern shipping routes in that month.

The Italian S. S. *Belvedere*, Capt. G. Gladulich, Buenos Aires, toward Trieste, reports a moderate gale experienced in latitude 32° 22′ S., longitude 51° 20′ W., on the 4th. Third Officer I. L. Uich states that the lowest barometric reading observed was 751.5 mm. (29.59 inches), at 8:50 a. m., wind ESE., force 7.

On the same date the American S. S. *Bird City*, Capt. H. Petersen, observer, Mr. Martin Marys, Philadelphia toward Buenos Aires, experienced a strong southerly gale with rough seas. The lowest pressure, 29.79 inches (corrected), was observed at 6:30 p. m., in latitude 31° 41′ S., longitude 51° 09′ W. Gale ended on the 4th, wind SSW. Highest force, 9; shifts SE. to SW.

Moderate to strong gales swept the southern coast of Brazil on the 5th, involving the Belgian S. S. *Londonier*, Capt. F. Paret, Antwerp, bound for Montevideo. Mr. W. R. A. Ezechials, observer, states that at 4 p. m., while in latitude 20° 03′ S., longitude 38° 58′ W., the pressure dropped from 29.66 inches to 29.56 inches (corrected), wind varying fron NE., force 4, to NNW., force 5, weather clear and cloudy. At 6 p. m. the vessel was apparently close to the center of the disturbance in latitude 20° 01′ S., longitude 39° 06′ W. At this time the lowest observed pressure was 29.47 inches (corrected), wind shifting from NW. to SW., reaching its maximum velocity of force 9, variable. During a very fierce electrical thunderstorm, followed by heavy continuous rain, the wind diminished to force 4 with a rising barometer.

On the 19th of November the Danish M. S. *California*, Capt. P. G. C. Pedersen, proceeding from Hull, England, toward Buenos Aires, experienced winds of gale force off the southern coast of Uruguay. Mr. J. L. Oster, observer, reports heavy seas and overcast weather. The lowest pressure, 29.31 inches (corrected), was observed at 4 p. m., in latitude 32° 20′ S., longitude 50° 30′ W., wind from SE. Highest force of wind 8, from S.; shifts SW., S., SE.

The Dutch S. S. *Waaldijk*, encountered this gale on the 18th while proceeding from Rio Grande do Sul to Montevideo, reporting conditions similar to those experienced by the *California*.

Occasional thick fog was reported by vessels on the 8th, 9th, and 19th off the southern coast of Brazil.

NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

Following upon the extremely stormy weather which characterized so many of the days of October, there came somewhat of a lull in the intensity of the winds, and reports indicate that not until early in December did full hurricane blasts again sweep the North Pacific Ocean.

November, however, could hardly be considered as a quiet month. The Aleutian LOW was generally well developed, and in consequence rough weather was experienced along the northern sailing routes. In addition, cyclonic or anticyclonic gales occurred in tropical waters off the Mexican coast and in the Far East. The activity of the winds may well be summarized in the statement that gales occurred daily over some part of the ocean, usually of force 7 to 9, but here and there rising to 10 or 11. It may be well to remark, however, that despite this considerable storminess, many a vessel accomplished its trans-Pacific voyage in fine weather without hindrance from wind and wave.

On the 1st day of November, and continuing into the 2d, gales occurred over the Japan Sea and along the China coast. Those in the more northern waters were caused by the passage of a cyclone across the archipelago to the eastward. In the Eastern Sea and continuing southward through the Formosa and Balintang Channels, the northeast monsoon, accentuated by the approaching continental anticyclone, was blowing with a force of 7 to 9. On the 7th, 8th, and 9th, according to reports from the Japanese S. S. *Keifuku Maru*, a moderate east-northeasterly gale was blowing over the northern portion of the China Sea.

On the 16th, 17th, and 18th, according to United States Weather Bureau weather maps a depression of considerable intensity was crossing the central Philippines. No vessel reports of the storm, which seems to have been a severe typhoon, have been received at this office, but an account of it, written by an official of the Philippine Weather Bureau, appears on page 597 of this REVIEW. This seems to have been the only tropical disturbance of the month.

Severe gales frequently swept the Gulf of Tehuantepec. At Salina Cruz they usually came from the north, but over the lower reaches of the gulf were variously from west-northwest to east-northeast. Vessel reports indicate gales of force 7 to 9 in this region on the 6th, 10th, 11th, and 12th. Those of the last three days were accompanied by a slight barometric depression. All were of a type peculiar to the locality.

Coming into the Hawaiian region, we find that two depressions, originating to the eastward, affected the weather of these islands. The first, an indefinite trough lying midway between Hawaii and California on the 4th, gathered some energy on the 5th and became central as a secondary depression to the southeastward of the Aleutian LOW, and near 40° N., 140° W. Several vessels in this region reported southeasterly gales, force 9 to 10, on the 5th. Farther to the southwestward northerly gales occurred. The American S. S. *Mauna Ala*, near latitude 26° N., longitude 148° W., experienced such a gale, force 8, with only a moderate depression of the barometer. At Honolulu the maximum wind velocity for November, 36 miles from the northeast, occurred at this time. The storm was dissipated, or combined with the Aleutian center, a day or two later. The second disturbance alluded to was probably generated to the eastward of Hawaii on the 16th and gave Honolulu its lowest pressure for the month. Few gales attended its slow northward movement.

Fine, clear weather prevailed over the Hawaiian Islands. This November was one of the warmest on record at Honolulu. The total rainfall was only 0.40 inch, or the second lowest in a record kept since 1877.

For the month as a whole pressure was below normal over the eastern part of the ocean, the largest relative departure occurring in the Aleutian area. At Dutch Harbor the average of the p. m. observations was 29.35 inches, or 0.24 inch below the normal. This was only a slight recovery from the record low pressure of the preceding month, when the departure was −0.41 inch. The highest reading, 29.94, was recorded on the 27th and 28th; the lowest, 28.82, on the 1st. The absolute range, 1.12 inches, was small for the time of year. At Midway Island the average pressure was 30.04 inches (28 days). This is 0.06 inch below the average for 12 years. There is a curious rise in pressure at this station in November, the normal for the month being 30.10 inches, whereas in October it is but 30.02 and in December 30.01. This year the highest reading, 30.30, was recorded on the 30th; the lowest, 29.72, on the 24th. Pressure was continuously below normal from the 15th to the 28th. At Honolulu the average p. m. pressure was 29.99 inches, or 0.03 inch below normal. The highest reading, 30.10, was recorded on the 27th; the lowest, 29.81, on the 16th.

The most frequent, as well as the strongest, gales experienced by vessels traversing the northern routes occurred between latitudes 40° and 50° N. and longitudes 160° E. and 170° W. This region lay in the southwestern quadrant of the average Aleutian center for November, and the strongest winds sweeping it were therefore largely from westerly to northwesterly directions. In the region to the southward of the Gulf of Alaska gales came more frequently from southwesterly to southeasterly directions.

The American cargo and passenger S. S. *Northwestern*, Capt. C. A. Glascock, Observer H. P. Timmers, third officer, cruised throughout the month in the waters of the northern part of the Gulf of Alaska. This vessel reported much rain and snow, and strong winds on the 5th, 8th to 11th, and 25th to 27th. On the 26th, while at Seward, a northeast gale, force 11, lowest pressure 28.53 inches, was encountered. The gale changed to southwesterly late on the 26th as the storm center moved northward into Alaska. The reading, 28.53 inches, was the lowest observed over the northern waters of the Pacific during the month.

Over the trans-Pacific routes the Japanese cyclone of the 1st gave some gales to the eastward up to the 4th, when it merged with the Aleutian center, then not far from 50° N., 175° E. The main gale area during the first three days of the month, however, was between 40° and 45° N., and 140° and 155° W. The highest wind force reported for this period was 10 from the west-northwest, lowest pressure 29.57, noted in 44° 12′ N., 147° 15′ W., by the British S. S. *Tascalusa*.

From the 5th to the 8th the Aleutian cyclone was over or to the eastward of Dutch Harbor, but on the 9th an eastward impulse carried the main storm center as a small LOW into eastern Alaska, while another center was gathering energy over the lower waters of Bering Sea. This in turn moved eastward, and from the 11th until the 14th occupied most of the Gulf of Alaska and adjacent waters to the southward, causing moderate to strong gales from near the Washington coast westward to the 170th meridian W.

The American S. S. *Eldridge*, Capt. F. W. Brooks, Observer R. B. Devenpeck, Taku, China, toward Seattle, was involved on the 8th to 11th in a cyclone which, on the 7th, was leaving the Japanese coast. On the 11th the wind, which was of irregular strength, attained its maximum observed force, 11 from the west-northwest, in 49° 55′ N., 178° 15′ W. From the 11th to the 13th the American S. S. *President Jefferson*, Capt. F. R. Nichols, Observer C. H. Moen, Orient toward Seattle, encountered rough weather, the highest wind force of which, SSE. 10, occurred in 52° N., 145° W., on the 11th. The Japanese S. S. *Fukuyo Maru*, Capt. A. Tokagi, Observer S. Terasaki, experienced a whole gale from the west-southwest in 39° 41′ N., 155° 34′ W., on the 13th, lowest pressure 29.48. The lowest pressure observed during the period, 7th to 14th, was 28.57 inches, read on board the British S. S. *Harold Dollar*, on the 13th, in latitude 46° 30′ N., longitude 161° W., during a strong north to northeast gale.

On the 16th the Aleutian LOW reached its maximum activity, and no gales were that day reported from northern waters. On the 17th the great storm center began to deepen and gales again set in to the southward of the Aleutians in both east and west longitudes. On the 18th pressure dropped below 29.00 inches at Dutch Harbor, and in latitude 47° 23′ N., longitude 172° 13′ E., the Japanese S. S. *Africa Maru* fell in with fresh to strong gales which culminated in a force of 11 from the west-by-north, lowest pressure 28.66 inches.

On both the 20th and 25th storms entered the ocean over northern Japan, occasioning gales over a considerable area to the eastward. Through the latter of these storms particularly, moderate to strong gales occurred from the 26th to the 28th over a stretch of sea embraced between the 35th and 45th parallels, 150th and 170th meridians of east longitude. On the 27th to the 30th the gale area extended between the 35th parallel and the Aleutians, as far eastward as 170° W.

Gales also occurred off the American coast to the northward of California on the 22d to the 24th, owing to the cyclone which, appearing to the westward of British Columbia on the 22d, moved inland on the 23d and 24th. But the highest wind velocities, force 10 from a northwesterly direction, noted over the main traversed routes during the last decade of November occurred on the 28th near 45° N., between 160° and 170° E., and were reported by the American S. S. *Dewey* and the British S. S. *Empress of Canada*.

At the close of the month an extensive anticyclone was moving eastward from Mongolia, and pressure was high in midocean below the 40th parallel, and along the central portion of the Hawaii-San Francisco route. A cyclone was central over the Kuriles, and another of considerable intensity lay at 8 p. m. of the 30th over the Gulf of Alaska.

Fog seems to have diminished considerably in frequency this month as compared with October. This decrease was especially noticeable in east longitudes, where fog was reported as having occurred on only five days over the area embraced between the 40th and 50th parallels and the 180th meridian and the Japanese coast. Some fog was reported in the eastern part of the Gulf of Alaska; near Puget Sound and Vancouver on six days; and outside San Francisco Harbor on four days.

FOUR TYPHOONS IN THE FAR EAST DURING OCTOBER, 1923.

By REV. JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

Four typhoons were shown by our weather maps of the Far East during the first half of the month of October, although only one of them influenced the weather in the Philippines, the other three being rather typhoons of the Ladrone or Caroline Islands. There was not a single typhoon noticed after the 12th.

The first typhoon appeared on the 2d to the south of Guam in about 10° latitude N. and 145° longitude E. It moved northwestward between Guam and Yap on the 3d; it inclined to NNW. on the 4th, and it probably filled up on the 7th not far from 134° or 135° longitude E., 23° or 24° latitude N.

The second typhoon was simultaneous with the preceding one and was quite clearly shown by the observations of Guam on the 3d and 4th. We have no means to decide whether it was a well-developed typhoon or only a depression. Its center was about 150 miles to the NNE. of Guam on the 3d, moving NW. It probably recurved northeastward on the 4th near 144° longitude E. and 18° latitude N. It was impossible to follow it after the 5th.

The third and most important typhoon of the month was shown by our weather maps on the 5th to the E. of central Luzon in about 130° longitude E. and near 16° latitude N. After moving slowly W. by N. for about two days, it took on the 7th a decided northerly direction, thus dispersing the danger for the Philippines; the center was then about 250 miles east of Luzon not far from 126° longitude E. The typhoon moved NNE. on the 8th and NE. on the 9th and the following days. When the center was passing close to the Loochoos on the 9th, our weather maps showed that it was a very well developed and intense typhoon. The center passed close to the southeastern coast of Japan on the 11th.

The approximate positions of the center at 6 a. m. of 8th to 11th are as follows:

October 8th, 6 a. m. 20° 30′ latitude N., 126° 20′ longitude E.
October 9th, 6 a. m. 24° 35′ latitude N., 127° 35′ longitude E.
October 10th, 6 a. m. 28° 25′ latitude N., 132° 15′ longitude E.
October 11th, 6 a. m. 33° 50′ latitude N., 139° 45′ longitude E.

The fourth typhoon was altogether simultaneous with the one of the Loochoos just mentioned. It appeared on the 5th and 6th to the NE. of Guam in about 17° latitude N. and 150° longitude E. It moved NNW. and recurved northeastward on the 9th. At 6 a. m. of the 9th the center was situated about 200 miles east of the Bonins.

A DESTRUCTIVE TYPHOON IN THE PHILIPPINES, NOVEMBER 16 TO 18, 1923.

By REV. JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

This typhoon was clearly shown by our weather map of the 15th, 6 a. m., about 200 or 250 miles to the east of the southern part of Samar near 139° longitude E. and 11° latitude N. It moved at the beginning W. by N., reaching the central part of Samar in the morning of the 16th. The center traversed Samar in a westerly direction, passing close to our stations of Borongan, Catbalogan, and Calbayog, and causing great damage

throughout that Province. At the time of writing this article, 10 days after the storm struck Samar, telegraphic communication has not been restored as yet to the eastern part of the island, where the lowest barometric minimum is supposed to have been recorded and the greatest damage done by the rains, winds, and sea waves. The barometric minima recorded at Catbalogan and Calbayog were, respectively: 714.85 mm. (28.14 inches) at 6:46 p. m. of the 16th, and 720.13 mm. (28.35 inches) at 8:33 p. m. of the 16th. The position of the center at 6 p. m. of the 16th was 124° 55′ longitude E. and 11° 50′ latitude N.

After crossing the island of Samar the typhoon began to incline to NW. and NNW., the center being situated at 2 p. m. of the 17th to the NE. of Romblon in about 122° 30′ longitude E. and 13° 20′ latitude N. At 6 a. m. of the 18th the center passed about 50 miles to the east of Manila along the eastern coast of Luzon, moving N. by W. or NNW. Then, in the afternoon of the same day, the typhoon inclined again westward and entered the China Sea during the night of the 18th to 19th not far from 16° latitude N.

The storm had lost much of its intensity after it traversed Samar, it being only a shallow depression when it crossed Luzon to the north of Manila. Yet considerable damage was done in many of the Provinces near the center by heavy rains and consequent floods. In Manila the total daily rainfall for the 18th and 19th was 278.5 mm. (10.96 inches) and 243.7 mm. (9.60 inches), respectively, and the flood, which was the worst of this year, caused the water to be 1½ meters high in some of the lower portions of the city.

Once in the China Sea the depression or typhoon, after moving for about one day almost due west, remained almost stationary or moved very slowly for two days about 150 miles to the west of central Luzon, at the same time inclining again to the N. Finally, on the 21st, it recurved NE. and ENE., passing through the Balintang Channel on the 22d and entering again in the Pacific in the afternoon or evening of the same day.

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

ALFRED J. HENRY.

The month, as a whole, presented no sharp extremes or pronounced departures from normal conditions; it was dry over the greater part of the area, especially in Pacific Coast States and also east of the Mississippi and south of the Ohio (see the inset on Chart IV). Due to the eastward movement of several shallow barometric depressions along the northern border, the temperature was above the average mainly in northern States (see Chart III). The usual details follow.

CYCLONES AND ANTICYCLONES.

By W. P. DAY.

There was an increase in the number of cyclones and anticyclones charted as compared with the preceding month. This is a normal tendency due to increased temperature gradients between polar and equatorial zones and a corresponding increase in the rapidity of air interchange between these regions. However, the low-pressure areas or cyclones with one or two exceptions were not important as storms, and the high-pressure areas, being largely of the north Pacific type, did not cause any important depressions of the temperature.

FREE-AIR SUMMARY.

By L. T. SAMUELS, Meteorologist.

A noticeable feature of the mean free-air temperatures for the month was the general continuation of like departures both in sign and magnitude from the surface to the highest altitudes reached by the kites. (See Table 1.) Ordinarily the departures become appreciably smaller with increasing altitude, with a tendency to approach zero. Climatological Chart III shows a striking contrast between large positive departures in the northern part of the country and negative departures in the South. Free-air departures are found to conform to these to a large extent.

Relative humidities averaged very close to their normals for all stations and levels.

Vapor-pressure departures followed, in general, those for temperature except at Ellendale, where a very considerable deficiency for the month was found. With the large positive temperature departures found at this station there would ordinarily be expected a considerable excess in the mean vapor pressures. However, this was not the case, there being only small positive departures from the surface to 1,500 m., above which they were negative. In this connection it is interesting to note that only 0.23 of an inch of precipitation occurred during the month, the smallest amount for November since the establishment of the station.

In Table 2 are shown the resultant wind directions and velocities for the month. Generally good agreement is found between the resultant direction as compared with the normals and the corresponding monthly temperature departure, that is, a positive temperature departure is usually accompanied by a more southerly or less northerly wind component than normally, and vice versa.

Resultant winds for the month based on afternoon pilot-balloon observations made at 10 regular Weather Bureau stations, in addition to six regular aerological stations, make possible the determination of the resultant atmospheric drift over the country as a whole. However, as yet, large sections, such as the Pacific coast and the plateau region, are inadequately represented by single stations, the Army and Navy stations not taking regular observations at this time of the year, and only comparatively low altitudes are obtained. At 1,000 m. above the surface these showed a westerly drift east of the Rocky Mountains except at Key West, south of west over New England and the Southern Plains States, north of west over the Missouri Valley, Denver, and Middle Atlantic States, due west over the Lake region and Memphis, east of north over San Francisco, north of east over Key West, and due east over San Juan and Curacao, Danish West Indies (the latter station being maintained through cooperation with the Dutch Government and located in latitude 12° N., longitude 69° W.). At 2,000 m. the direction was north of west at all mainland stations except Burlington, where it remained S. 57° W. and due east at San Juan and south of east at Curacao. At 4,000 m. this continued, with the exception of San Francisco, which became east of north, San Juan at this level also being slightly north of west, while Curacao remained south of east. Practically no change was found at 5,000 m. except at Curacao, which became

slightly north of east. Above this level the number of observations decreases rapidly and therefore reliable resultants can not be determined. It is interesting to note, however, that those based on what observations were made are remarkably consistent in that they show a general drift of about N. 20° W. over all the stations except San Francisco, which continued east of north to 8,000 m., and Key West and San Juan, where a more nearly west direction was found. At Curacao a turning to north occurred, becoming slightly west of north above 8,000 m. There is a clear evidence in these higher levels of the resultant directions turning to westerly at successively higher altitudes from higher to lower latitudes.

On the 3d, when an area of high pressure was centered over New England and the Middle Atlantic States, Burlington and Washington, being within the region of highest pressure, obtained high balloon ascensions which were in extremely close agreement throughout. A southerly wind was found at the surface, first increasing in velocity to about 10 m. p. s. between 2 and 3 kilometers, then decreasing to nearly calm at about 5 kilometers where a veering to northwest occurred. This upper wind increased rapidly at both stations, reaching a velocity of 34 m. p. s. at 12 kilometers above Washington.

On the 5th when an extensive Pacific HIGH covered the country west of the Mississippi River, aerological observations made at the stations under its control revealed its influence to considerable altitudes. This area of high pressure moved slowly across the country, overspreading a vast amount of territory. A deep northerly current prevailed to the east of its center with north and northeast winds extending to at least 8,000 m. on some days. On the 10th two centers were apparent, Ellendale being situated northwest of the center which was over Wyoming. The afternoon balloon observation at this station showed a moderate northwest wind at the ground with decreasing velocity to 5,000 m., where practically a calm obtained, above which a moderate east wind prevailed to 9,600 m., the limit of the observation. The following morning showed a complete reversal, i. e., a moderate south wind at the ground becoming strong at 3,500 m., the highest level reached. On the 11th, when the center of the HIGH had moved to Madison, Wis., light winds were found to 10,000 m., the direction mostly north changing to northeast at 9 and 10 kilometers. By the next day a similar reversal occurred, showing moderate to strong south winds from the ground to 5,000 m., the top of the observation. On this date (12th), Lansing, south of the center, had a moderate east wind from the ground to 8,000 m., above which the direction was northwest to 13,000 m. At this station the following date showed also a change to south from the ground to 5,000 m. Above this, however, the northwest current obtained to at least 14,000 m.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during November, 1923.*

TEMPERATURE (° C.).

Altitude. m. s. l. (*m.*)	Broken Arrow, Okla. (233 *m.*) Mean.	Departure from 6-yr. mean.	Drexel, Nebr. (396 *m.*) Mean.	Departure from 9-yr. mean.	Due West, S. C. (217 *m.*) Mean.	Departure from 3-yr. mean.	Ellendale, N. Dak. (444 *m.*) Mean.	Departure from 6-yr. mean.	Groesbeck, Tex. (141 *m.*) Mean.	Departure from 6-yr. mean.	Royal Center, Ind. (225 *m.*) Mean.	Departure from 6-yr. mean.
Surface	9.1	−0.7	4.7	+1.1	9.2	−2.4	2.5	+4.5	12.2	−0.8	5.3	+0.3
250	9.0	−0.7			9.1	−2.3			12.0	−0.8	5.2	+0.4
500	8.8	+0.1	4.7	+1.2	8.2	−2.2	2.7	+4.7	11.5	−0.7	4.2	+0.8
750	8.1	+0.2	4.8	+1.6	7.1	−2.2	3.7	+5.5	10.7	−0.9	3.3	+0.8
1,000	7.4	0.0	4.7	+1.5	7.0	−1.6	3.8	+5.2	10.0	−1.1	2.6	+0.7
1,250	6.5	−0.4	4.1	+1.1	7.0	−1.1	3.0	+4.4	9.2	−1.1	1.9	+0.4
1,500	5.4	−0.8	3.2	+0.7	6.2	−1.1	2.4	+4.1	8.4	−1.2	1.4	+0.4
2,000	3.3	−1.0	1.3	+0.5	4.5	−1.2	0.4	+3.7	6.8	−0.8	−0.5	+0.2
2,500	1.0	−1.2	−1.1	+0.4	2.6	−1.1	−2.0	+3.5	4.9	−0.6	−2.5	0.0
3,000	−1.5	−1.4	−3.6	+0.6	0.2	−1.1	−4.6	+3.4	2.7	−0.4	−4.7	0.0
3,500	−3.6	−1.1	−6.1	+0.8	−2.1	−0.7	−7.3	+3.5	0.2	−0.1	−6.8	−0.1
4,000	−5.6	−0.7	−8.9	+0.8	−4.5	−0.3	−10.3	+3.4	−2.5	0.0	−9.3	+0.3
4,500	−8.4	−1.0	−11.4	+0.9			−13.1	+3.4	−5.9	−0.4	−12.1	+0.3
5,000	−11.0	−1.0	−14.2	+1.0					−9.9	−1.2		

RELATIVE HUMIDITY (PER CENT).

Altitude. m. s. l. (*m.*)	Broken Arrow Mean.	Departure	Drexel Mean.	Departure	Due West Mean.	Departure	Ellendale Mean.	Departure	Groesbeck Mean.	Departure	Royal Center Mean.	Departure
Surface	73	+6	71	−1	70	+2	73	−7	75	+1	72	−2
250	72	+5			70	+2			72	0	72	−2
500	63	0	68	−1	67	+2	71	−7	65	−2	68	−5
750	58	−2	61	−3	64	+2	63	−9	61	−2	65	−5
1,000	56	−2	56	−3	60	0	58	−8	59	−1	63	−3
1,250	52	−2	51	−4	57	−1	55	−6	56	−1	62	+1
1,500	49	−1	49	−4	56	−1	51	−6	52	−2	58	+1
2,000	45	−1	46	−4	54	+4	45	−8	41	−8	53	+1
2,500	46	+2	46	−4	51	+4	43	−9	37	−8	52	+4
3,000	45	+2	46	−5	49	+4	43	−9	35	−6	54	+8
3,500	40	0	45	−7	49	+3	43	−10	35	−5	54	+9
4,000	32	−3	46	−6	49	+3	46	−9	32	−5	58	+17
4,500	33	+2	49	+1			50	−6	32	−4	54	+17
5,000	34	+2	51	+6					33	−2		

VAPOR PRESSURE (*mb.*).

Altitude. m. s. l. (*m.*)	Broken Arrow Mean.	Departure	Drexel Mean.	Departure	Due West Mean.	Departure	Ellendale Mean.	Departure	Groesbeck Mean.	Departure	Royal Center Mean.	Departure
Surface	8.20	−0.01	6.11	+0.27	7.43	−1.85	5.39	+0.82	10.55	−1.20	6.40	−0.29
250	8.14	0.00			7.32	−1.81			10.03	−1.28	6.32	−0.29
500	7.26	−0.10	5.83	+0.24	6.58	−1.62	5.32	+0.83	8.80	−1.40	5.54	−0.35
750	6.34	−0.40	5.28	+0.23	5.88	−1.48	4.91	+0.75	7.72	−1.44	5.02	−0.28
1,000	5.83	−0.43	4.78	+0.18	5.47	−1.30	4.44	+0.61	7.02	−1.30	4.56	−0.14
1,250	5.09	−0.63	4.22	−0.05	4.89	−1.25	4.00	+0.47	6.30	−1.12	4.16	−0.01
1,500	4.46	−0.67	3.71	−0.23	4.43	−1.16	3.57	+0.32	5.62	−1.00	3.68	−0.02
2,000	3.54	−0.58	3.01	−0.25	3.81	−0.50	2.72	−0.03	4.13	−0.98	2.86	−0.13
2,500	3.05	−0.25	2.50	−0.23	3.22	−0.33	2.24	−0.10	3.44	−0.50	2.45	+0.13
3,000	2.59	−0.16	2.00	−0.30	2.71	−0.20	1.84	−0.10	2.90	0.00	2.15	+0.08
3,500	1.97	−0.12	1.64	−0.25	2.55	−0.04	1.50	−0.09	2.62	+0.36	1.73	+0.05
4,000	1.34	−0.11	1.41	−0.11	2.13	+0.02	1.30	−0.03	2.30	+0.69	1.31	+0.63
4,500	1.13	+0.13	1.28	+0.11			1.18	−0.05	2.14	+1.05	0.82	+0.63
5,000	0.96	+0.13	1.16	+0.33					2.08	+1.30		

TABLE 2.—*Free-air resultant winds (m. p. s.) during November, 1923.*

Altitude, m. s. l. (*m.*)	Broken Arrow, Okla. (233 meters). Mean. Dir.	Vel.	6-year mean. Dir.	Vel.	Drexel, Nebr. (396 meters). Mean. Dir.	Vel.	9-year mean. Dir.	Vel.	Due West, S. C. (217 meters). Mean. Dir.	Vel.	3-year mean. Dir.	Vel.
Surface	S. 71° W.	1.0	S. 44° W.	1.0	S. 50° W.	1.3	S. 82° W.	1.3	N. 18° W.	1.4	N. 63° W.	0.7
250	S. 72° W.	1.1	S. 39° W.	1.0					N. 7° W.	1.5	N. 60° W.	0.7
500	S. 72° W.	1.9	S. 26° W.	2.2	S. 82° W.	1.9	S. 86° W.	2.0	N. 10° W.	2.0	N. 70° W.	1.2
750	S. 73° W.	2.9	S. 32° W.	2.9	N. 81° W.	3.3	N. 89° W.	3.5	N. 7° W.	2.2	N. 75° W.	1.7
1,000	S. 87° W.	4.0	S. 46° W.	3.5	N. 74° W.	5.2	N. 89° W.	4.8	N. 31° W.	2.0	N. 82° W.	2.4
1,250	N. 87° W.	4.0	S. 55° W.	4.3	N. 75° W.	5.5	N. 87° W.	5.7	N. 48° W.	2.7	N. 81° W.	3.6
1,500	N. 84° W.	4.3	S. 63° W.	4.7	N. 76° W.	6.3	N. 86° W.	6.7	N. 63° W.	3.3	N. 85° W.	4.9
2,000	N. 73° W.	4.6	S. 70° W.	6.2	N. 76° W.	7.9	N. 83° W.	7.8	N. 68° W.	4.6	N. 86° W.	7.0
2,500	N. 78° W.	5.3	S. 78° W.	6.9	N. 77° W.	10.0	N. 80° W.	9.4	N. 63° W.	6.6	W.	8.9
3,000	N. 81° W.	6.4	S. 77° W.	8.5	N. 71° W.	10.9	N. 78° W.	10.7	N. 68° W.	6.9	N. 87° W.	10.4
3,500	N. 79° W.	7.5	S. 80° W.	8.8	N. 69° W.	10.1	N. 75° W.	11.3	N. 87° W.	9.4	W.	12.7
4,000	N. 83° W.	8.7	S. 82° W.	10.8	N. 73° W.	8.8	N. 80° W.	12.5	S. 78° W.	9.6	N. 85° W.	14.4
4,500	N. 72° W.	8.0	S. 89° W.	9.8	N. 49° W.	4.2	N. 84° W.	12.6				
5,000	S. 82° W.	14.0	S. 64° W.	12.6	N. 18° W.	8.0	N. 81° W.	11.3				

Altitude, m. s. l. (*m.*)	Ellendale, N. Dak. (444 meters). Mean. Dir.	Vel.	6-year mean. Dir.	Vel.	Groesbeck, Tex. (141 meters). Mean. Dir.	Vel.	6-year mean. Dir.	Vel.	Royal Center, Ind. (225 meters). Mean. Dir.	Vel.	6-year mean. Dir.	Vel.
Surface	S. 85° W.	3.1	N. 52° W.	2.0	N. 14° E.	0.5	N. 35° E.	0.4	S. 67° W.	1.0	S. 40° W.	1.6
250					N. 33° E.	0.2	N. 75° W.	0.5	S. 68° W.	1.1	S. 52° W.	2.5
500	S. 77° W.	2.4	N. 63° W.	2.2	S. 15° W.	0.9	S. 24° E.	0.9	S. 66° W.	2.0	S. 54° W.	4.4
750	S. 84° W.	4.6	N. 64° W.	3.7	S. 36° W.	1.4	S. 20° W.	1.4	S. 74° W.	2.2	S. 61° W.	5.6
1,000	N. 86° W.	5.6	N. 67° W.	4.6	S. 61° W.	1.3	S. 46° W.	1.9	N. 85° W.	2.8	S. 67° W.	6.4
1,250	N. 77° W.	7.2	N. 69° W.	5.5	N. 86° W.	1.7	S. 63° W.	2.7	N. 77° W.	3.6	S. 71° W.	7.3
1,500	N. 72° W.	7.7	N. 67° W.	6.6	N. 69° W.	1.9	S. 71° W.	3.5	N. 84° W.	3.8	S. 74° W.	7.9
2,000	N. 70° W.	7.7	N. 67° W.	8.2	N. 58° W.	3.7	S. 82° W.	4.9	N. 61° W.	4.9	S. 82° W.	9.2
2,500	N. 69° W.	9.2	N. 65° W.	10.7	N. 65° W.	5.1	S. 87° W.	7.0	N. 59° W.	6.8	S. 83° W.	11.1
3,000	N. 70° W.	11.8	N. 67° W.	12.6	N. 65° W.	5.7	S. 86° W.	8.4	N. 60° W.	8.5	N. 87° W.	12.4
3,500	N. 72° W.	12.9	N. 66° W.	13.6	N. 63° W.	7.0	S. 75° W.	10.2	N. 84° W.	9.9	N. 86° W.	12.1
4,000	N. 70° W.	14.2	N. 65° W.	12.9	N. 80° W.	7.7	S. 70° W.	8.7	N. 62° W.	6.9	S. 89° W.	10.0
4,500	N. 78° W.	17.8	N. 60° W.	15.8	S. 82° W.	13.5	S. 66° W.	10.2	N. 46° W.	5.3	N. 71° W.	7.6
5,000												

THE WEATHER ELEMENTS.

By P. C. DAY, Meteorologist, In Charge of Division.

PRESSURE AND WINDS.

The most pronounced feature of the atmospheric pressure distribution during the month was the persistent maintenance of anticyclonic conditions over the middle Rocky Mountains and adjacent districts, extending westward nearly to the coasts of Washington and Oregon. With a single exception of short duration, these conditions existed throughout the first two decades and also during most of the third. As a result of this, cyclones moving southeastward from the North Pacific approached the coast districts farther north than is usual in November and moved toward the Atlantic coast mainly to northward of the international boundary.

No important anticyclones entered the United States from Canada east of the Rocky Mountains during the entire month, the main source of these being the north Pacific coast. As anti-cyclones from this locality are usually not associated with low temperatures there were no important cold waves during the month.

Cyclones were unimportant in the main, and few had extensive tracks or covered wide areas.

A somewhat indefinite cyclone, but one probably maintaining its identity over the longest track, was present at the beginning of the month in the far Southwest, and during the following three or four days extended eastward to the Atlantic coast. This caused some snow at the higher elevations of Arizona and New Mexico, and general rains to the eastward, extending into the Ohio Valley and lower Lake regions. Heavy rains attended this storm in portions of the Gulf States during the 3d and 4th, and in some south Atlantic coast districts during the 4th and 5th.

Considerable rain occurred over the Northeastern States on the 7th and 8th due to the sudden development of a cyclone over that region. About the 10th, low pressure again developed over the far Southwest, and moved slowly northeastward to the region of Lake Superior, attended by some heavy rains in Arizona, but elsewhere over its path precipitation was mainly light. This storm, after passing into Canada to northward of the Great Lakes, moved as an indefinite cyclone to the southeast and again entered the United States over the lower Lake region and moved northeastward to the coast, attended by light local rains.

On the 22d cyclonic conditions developed in the Southern Plains and, increasing somewhat in intensity, moved eastward and northeastward to the Atlantic coast, attaining considerable severity off the southern New England coast on the morning of the 24th. This storm brought rather widespread precipitation from the Mississippi River eastward, with local heavy falls in some Northeastern States, greatly relieving the accumulated shortage of precipitation that had persisted over that section during much of the summer and fall. As the ground was unfrozen at the time it permitted a large absorption and favored a satisfactory replenishment of the underground water supply.

On the 28th general rains set in over the Gulf coast sections and by Thanksgiving morning a storm of considerable intensity was central in the middle Mississippi Valley, whence it moved by the morning of the 30th to the Great Lakes, attended by precipitation over most districts from the Mississippi Valley eastward.

Except for occasional rains in the far Northwest and occasional local snows in the mountains, the greater part of the month was unusually free from storms of any character over much of the western part of the country. About the 29th, however, precipitation set in over the North Pacific States and at the end of the month considerable rain or snow had occurred from the northern Rocky Mountains westward to the coast.

Compared with the normal the average sea-level pressure for the month was above over much of the country, the excess being large in the middle Rocky Mountain section, and thence northwestward to the coast of Washington and southeastward to western Texas. Pressure was generally less than normal over the Canadian Northwest and the adjacent portions of the United States as far east as Lake Superior. It was also below normal over the Atlantic coast districts from southern New England to Florida and along the immediate coast of California.

From October to November the average pressure usually increases over all portions of the United States and Canada save for a small area along the Washington coast. In November, 1923, the average pressure was far less than that for October preceding over the Canadian Provinces from the Rocky Mountains to the Great Lakes, extending southward over the United States to the middle Mississippi Valley and thence eastward, though here the depression was less pronounced. Over the Gulf States pressure was higher than in October, as is usual, and similar conditions existed to westward of the Rocky Mountains.

Due to the pressure distribution the prevailing winds over the Gulf and Atlantic Coast States were mainly from northerly points, while over the Great Plains, upper Mississippi Valley, and the Great Lakes they were from southerly points. In California and Oregon they were frequently from the north.

TEMPERATURE.

Unusually cold weather for the season prevailed at the beginning of November in the Great Plains and adjacent regions, with temperatures below freezing in northern Texas and near zero or slightly lower in portions of the middle Rocky Mountain region.

Cold weather continued generally throughout the week ending November 6, from the middle Rocky Mountain and Plateau regions eastward to the Ohio Valley, averaging from 8° to 10° below the normal over this area, and reaching an extreme of 18° below in central Wyoming. However, in portions of the northern border States east of the Rocky Mountains and along the Pacific seaboard the temperatures for the week were above the normal. Freezing temperatures occurred as far south as the northern portions of the Gulf States and central North Carolina and Virginia.

During the week ending the 13th, conditions were largely the reverse of those for the preceding week, abnormally high temperatures for the season prevailing in the northern and central districts from the Mississippi Valley westward, with unusually low temperatures in the southeast sections of the country, the averages ranging from 6° to 14° above the normal in the Great Plains and from 8° to 10° below along the South Atlantic coast.

Freezing temperatures occurred as far south as the central portions of the east Gulf States, while in the west Gulf States they did not fall to the freezing point, but in the interior of New England temperatures as low as 14° were recorded. Light frosts occurred in the interior of Florida, with weather near freezing in the northern part of the State.

Temperatures for the week ending November 20 averaged above normal except in much of the South Atlantic

and Gulf States. Unusually warm weather for the season prevailed in the Northern and Central States, the averages reaching 16° above the normal in the northern portion of the Great Plains. On the other hand freezing weather was again reported as far south as central South Carolina, but temperatures as low as 32° were not recorded in the lower Ohio Valley or south of the central Mississippi Valley. The lowest reported was 4° at Lander, Wyo., where the temperature remained unusually low, due largely to a persistent snow cover and atmospheric conditions favorable for rapid night radiation.

The weather during the week ending the 27th was generally free from sudden changes and the temperature averaged above normal in practically all sections of the country, except Florida, where it was slightly below. However, rather cool weather prevailed at the beginning of the week in the Northeast and Appalachian Mountain districts, but within a few days much warmer weather overspread these regions. At the same time considerably cooler weather overspread the Great Plains and by the middle of the week had passed over the Great Lakes and northeastern districts, while the weather had become much warmer over the Northwest. Near the close of the week relatively high temperatures prevailed in the interior States, except that a moderate cold wave had overspread the central and northern Plains.

Temperatures during this week averaged considerably above normal from the west Gulf States northward over the Great Plains and also throughout the Pacific Coast States; in portions of California they averaged from 7° to 10° a day above normal. Freezing weather occurred in the Southeast as far as central Georgia, but in the Mississippi Valley temperatures below 32° were not reported south of St. Louis, Mo.

During the last few days of the month there was a sharp rise in temperature in the more northwestern States, with readings 10° to 12° above the seasonal average, while warmer weather prevailed over the Middle Atlantic States, but freezing temperatures prevailed on the 30th in the Rio Grande Valley.

The month as a whole was unusually warm, except over a small area in central Wyoming, and in the South where in some sections the temperatures averaged several degrees below the normal. In portions of the Northwest they averaged from 8° to 10° a day above the normal and in the adjacent portions of Canada they were from 12° to 16° above.

Over many northwestern sections the month was almost continuously warmer than normal, several stations in the Dakotas and Montana having no days with the average temperature below normal, and many stations in adjacent States had but one or two days cooler than normal.

The month was remarkably free from sudden changes in temperature; in but few instances did the 24-hour changes equal or exceed 30°, and these occurred in the Northwest or Rocky Mountain districts where the daily changes are liable to be large at this season of the year.

On account of the comparative freedom from sudden or important temperature changes no single period showed the highest temperatures of the month over extensive areas, and these occurred in practically all parts of the month for different areas.

The lowest temperatures were likewise well distributed through the month, though mostly during the last decade.

PRECIPITATION.

The month as a whole was remarkably free from extended periods of cloudy or rainy weather and in portions of the northern and central districts from the Mississippi River westward there were long periods having all the characteristics of the so-called Indian summer.

In general, precipitation, though below normal over large areas, was mainly ample for present needs, and in the more northeastern districts was sufficient to relieve a threatened shortage of the winter water supply. In some districts, however, the fall was insufficient, notably in portions of Florida where it was with one or two exceptions the driest November in 50 years or more. Drought likewise prevailed over much of California and more rain was badly needed in that State at the end of the month.

For the month as a whole precipitation was above normal over all districts from Arizona and southern Utah eastward to the central Gulf States, and generally over New England. There was less than the normal fall over the Atlantic Coast States from New York to Florida, and from the Ohio Valley and Great Lakes westward to the Pacific coast. From central California northward to Washington there were large deficiencies in the monthly totals, as compared with the normals, reaching 7 inches in portions of the Puget Sound district. On the other hand there were some unusually heavy falls locally in Arizona, New Mexico, Texas, and Alabama. The largest total for the month, 14.69 inches, was reported from Louisiana.

SNOWFALL.

November, as a rule, had but little snow over the lower elevations, particularly in the upper Lake region and over the Northeastern States where the heaviest falls for November, east of the Rocky Mountains, usually occur.

On the 8th light falls occurred over the northern border States from the Great Lakes eastward, and a few days later there were local falls in northern Arizona and the adjacent portions of Utah and Nevada. About the 23d to 26th considerable snow fell from the upper Mississippi Valley eastward to New England and portions of the Canadian Maritime Provinces. Beginning on the 27th snow overspread the panhandle region of Texas and adjacent sections, and during the 28th and 29th extended into eastern Kansas, southern Iowa and the western portions of Arkansas and Missiouri. Locally in eastern Kansas the fall was the greatest ever known in November, in fact greater than had been reported for the entire month of November for any previous year.

In the mountain sections of the West there was a very generous fall over the greater part of New Mexico and southern Colorado, also in western Wyoming, Idaho, and eastern Oregon.

In California, however, the season's snowfall to the end of November had been small and only the highest portions of the Sierra Nevada were snow covered at the end of the month.

RELATIVE HUMIDITY.

Like precipitation, the relative humidity for the month was above the seasonal average over the greater part of the southern portion of the country. In some of the more southwestern regions the excess ranged from 10 to 15 per cent, while generally in California the deficiencies were equally great. In the northern and central districts the departures from the seasonal averages were generally small, but on the whole they were of a positive character, even in the far Northwest where the deficiency in precipitation was large.

SEVERE LOCAL STORMS, NOVEMBER, 1923.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau.]

Place.	Date.	Time.	Width of path (yards).	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
Bayou Little Caillou, La. (16 miles south of Houma, La.).	28	9 p.m.		5		Tornado	Several dwellings destroyed and also a school building valued at $25,000: considerable damage to crops: several persons injured.	Official, U. S. Weather Bureau.
New Orleans, La.	28	10:15 p.m.			$20,000	Wind	1 residence demolished and several others damaged.	Do.
Latham, Ala. (1 mile north of).	29	8 a.m.		1	12,000	Tornado	2 persons injured; several buildings demolished and many trees uprooted or twisted off.	Do.

STORMS AND WEATHER WARNINGS.

WASHINGTON FORECAST DISTRICT.

By EDWARD H. BOWIE, Supervising Forecaster.

The month of November gave no wind and weather conditions out of the ordinary for this month in the Washington Forecast District. The number of storms which crossed the eastern half of the country was not in excess of the normal, and few of these were other than disturbances of moderate intensity. There were no cold waves, which is exceptional, for scarcely a November passes without the necessity of displaying cold-wave warnings in some part of the district. Frosts were frequent, however, and occurred in all parts of the district except southern Florida. Perhaps the notable feature of the month was the number of well-developed areas of high barometric pressure which crossed the district, but as these were HIGHS that came eastward from the far West, many coming into the country from the Pacific Ocean, they were not attended by the pronounced and rapid falls in temperature associated with the HIGHS that come down from Canada.

Storm warnings were displayed during the month as follows: Small craft warnings on the 2d and 3d for the Mobile and Pensacola storm warning districts and on the 4th for the Atlantic coast at and between the Virginia Capes and Cape Hatteras, advisory warnings on the 6th for the Middle Atlantic and New England coasts followed by the display of storm warnings on the 7th at and between the Virginia Capes and Eastport, Me.; northeast storm warnings on the 12th at and between Delaware Breakwater and Cape Hatteras and these were continued on the 13th at and between the Virginia Capes and Cape Hatteras; northeast storm warnings were displayed on the 23d along the coast at and north of Delaware Breakwater and these were continued on the 24th at and north of Boston, Mass.; small-craft warnings on the 29th for the Mobile and Pensacola districts; and on the 30th, southeast storm warnings were displayed on the Atlantic coast at and north of Delaware Breakwater. Practically all of these warnings were verified, although in no instance did a storm of marked severity occur. Of the storms that did occur the one on the 6th and 7th, which came northeastward from the east Gulf coast as a moderate disturbance and then after reaching New Jersey increased greatly in intensity, and that of the 24th which developed over the Middle Atlantic States on the night of the 23d, were the most important. In both of these instances, the development of energetic disturbances in the troughs of low pressure between two HIGHS (one to the east or northeast and the other to the west or northwest of the places where these developments took place) were the preliminary pressure situations previously to the increase in intensity of these two disturbances. The display of warnings on the 12th was in connection with the rapid development and southward movement of an area of high barometric pressure from the New England States at a time when the barometric pressure was low off the Middle Atlantic and South Atlantic coast, a distrubance developing in this region of low air pressure on the 14th and moving east-northeastward, the pressure falling to 29.56 inches at Bermuda on the 15th. The display of warnings on the 30th was in connection with a disturbance which developed over the Gulf of Mexico, moved thence up the Mississippi Valley to the region of the Great Lakes and thence east-northeastward down the St. Lawrence Valley with diminished intensity. In addition to the advices sent to ports, all advices concerning the position, intensity, and the direction of movement of these storms, together with expected winds and weather, were broadcast to ships at sea through naval radio.

CHICAGO FORECAST DISTRICT.

In the Chicago Forecast District November, 1923, was virtually free from atmospheric disturbances of severity. While it was necessary to issue storm warnings for the Great Lakes on several occasions, and a few cold-wave warnings for the northern States of the district, yet in no instance did the ensuing conditions become intense.

Storm warnings.—Northwest storm warnings were issued on the morning of the 7th, for Lakes Huron, Erie, and Ontario, and small-craft warnings for northern Lake Michigan and extreme eastern Lake Superior. At that time a disturbance that had developed off the Middle Atlantic coast during the preceding 24 hours was central over Massachusetts. Within the same period a substantial increase in pressure had taken place over the northwestern upper Lake region with the result that a rather pronounced gradient existed from that section eastward to the storm center. The disturbance moved northeastward on the 7th with a still further development, and strong winds or moderate gales occurred over most of the area where warnings were displayed.

No further storm warnings were needed until the 19th, but in the meantime small-craft warnings were advised on the 10th for the lower Lakes, Lake Huron, and eastern Lake Michigan, on the 16th for Lake Huron, eastern Lake Michigan, and eastern and central Lake Superior, and on the 17th for the same districts as on the 16th, excepting southeastern Lake Michigan, for disturbances of moderate character that were expected to affect the sections in question. On the night of the 19th a disturbance from the Northwest was moving rapidly southeastward over Manitoba with increasing energy and a central pressure of 29.44 inches. Accord-

ingly, southwest warnings were issued for Lake Superior and northern Lake Michigan, and on the following morning the warnings were extended to include the remainder of the Great Lakes. The center of the storm passed eastward just to the north of the Lakes on the 20th, with gradually decreasing energy. Within the period covered by the warnings strong winds occurred rather generally, with verifying velocities at about one-half the stations.

The next disturbance to call for warnings was central on the morning of the 23d, over Ohio. At that time but little energy was evident, but the pressure in and near the center of the storm was decreasing rapidly. Small-craft warnings were advised for Lakes Erie and Ontario. Noon special observations, however, indicated a marked increase in intensity, Erie, Pa., reporting a wind velocity of 48 miles an hour from the southeast, and a 2-hour pressure fall of 0.14 of an inch. Therefore, southeast storm warnings were substituted for the small-craft warnings on Lake Ontario and on Lake Erie from Erie, Pa., eastward. The warnings were lowered a few hours later, however, the night reports indicating that the disturbance was losing energy. No verifying velocities other than that referred to in the foregoing were reported.

On the morning of the 25th a disturbance from the Northwest was central in northern Minnesota with increasing strength. Small-craft warnings were then issued for Lake Superior and northern Lake Michigan, but at 2 p. m. northwest storm warnings were substituted. At night the warnings were extended over the remainder of the Lakes, southwest warnings being displayed on the Lower Lakes. The storm continued its eastward movement, but it lost energy after the morning of the 26th. Generally speaking, the warnings were verified on the Upper Lakes, but on the Lower Lakes only fresh to strong winds occurred.

Another disturbance from the Northwest was central over northern Manitoba on the morning of the 28th and it appeared to call for southwest warnings on Lake Superior and the northern portions of Lakes Michigan and Huron. Accordingly, these were issued. The warning was verified in part, moderate gales being reported from central Lake Superior.

The final storm warning for the month was issued on the 29th for a disturbance that had moved up the Mississippi Valley from the Gulf of Mexico to a position central on the morning of that date near Memphis, Tenn., and with a marked increase in intensity. At 2 p. m. northeast warnings were issued for Lake Michigan, and southeast warnings for Lake Huron. At night the warnings were extended over the Lower Lakes, southeast warnings being displayed. This storm moved north-northeastward from Memphis. As it reached the Lake Region the disturbance decreased in intensity, but it caused gales over portions of Lake Erie on the night of the 29th–30th.

Cold-wave warnings.—Coldwave warnings were issued as follows: On the 20th, for North Dakota, northern Minnesota, northern and eastern upper Michigan, and extreme northern lower Michigan; on the 25th, for North Dakota and northwestern Minnesota; and on the 30th, for Montana, Wyoming, the Dakotas, and northern Minnesota. For the most part these warnings were verified but, as indicated in the first part of this report, the cold was not severe.

Frost warnings.—Frost warnings were issued on a number of dates until the 21st for southeastern Kansas. The frosts that occurred were apparently of little economic importance.

Stock warnings.—Warnings for stock interests were issued on the last day of the month for the Dakotas, western Nebraska, Montana, and Wyoming in connection with the expected occurrence of snow and much colder weather in those States. In general, ensuing conditions were as predicted; however, little or no snow fell in South Dakota and western Nebraska.

Forecasts for the benefit of beekeepers in this district were begun on a small scale. The necessary arrangements were not completed until near the middle of the month and only one special forecast was issued. It is understood that plans are under way to extend this forecast service to the entire country where it is not already in operation. The work is being carried out by the American Honey Producers' League with headquarters at Madison, Wis. The particular information desired by those in the Chicago district is a forecast in November of a day or two with a temperature of 50° or higher and clear weather, followed by cloudy and colder.—*C. A. Donnel.*

NEW ORLEANS FORECAST DISTRICT.

Moderate weather conditions prevailed over this district during the month. Frost or freezing warnings were issued for interior portions of the district on the 3d, 4th, 5th, 6th, 7th, 15th, 16th, 17th, 19th, 21st, and 26th. Livestock warnings on the 27th were issued for snow for Oklahoma and the northern portion of west Texas, and Amarillo, Tex., reported 9.0 inches of snow on the ground on the 28th.

Small-craft warnings were displayed on the Texas coast on the 1st, 2d, 26th, 27th, and 28th, and northeast storm warnings for the Galveston section on the 28th, all of which were justified. No storm occurred without warning.—*I. M. Cline.*

DENVER FORECAST DISTRICT.

During the greater part of the month, areas of high pressure occupied the middle portion of the Rocky Mountain region, with frequent LOWS of considerable intensity passing across western Canada and the upper Missouri Valley and occasional disturbances moving eastward along the southwestern border. A storm of marked intensity that appeared over southern California on the 9th moved rapidly northeastward during the 10th and 11th and was attended by general precipitation in all portions of the district except eastern Colorado, with occasional excessive downpours in Arizona on the 10th.

A moderate cold wave, without warning, occurred in southeastern and extreme eastern Colorado on the 26th, due to the passage of an area of relatively high pressure across that portion of the State. Local cold waves, also without warning, occurred at Pueblo on the 21st and 28th.

Frost warnings were issued as follows: 2d, southern New Mexico and southeastern Arizona; 3d, southern New Mexico, heavy to killing northwestern Utah; 4th, heavy northern Utah; 5th and 6th, south-central and

southeastern New Mexico, heavy northern Utah; 7th, south-central New Mexico; 19th, south-central and southeastern New Mexico; 26th and 27th, south-central and southeast Arizona; 28th, south-central Arizona, freezing temperature southeast Arizona.

The warnings were generally verified by the actual occurrence of frost or temperatures at which frost might be expected.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT.

November, 1923, was a comparatively quiet month from a weather standpoint on the Pacific coast. The storm movement, like that of the preceding month, was well to the north and the precipitation light and mostly confined to western Washington. The only important feature was the storm of the 28th–30th. This was a small depression which moved southward over the intermountain region to southern Nevada and thence southwestward, passing off the southern California coast in the vicinity of San Diego. It caused a strong northeast gale along the central California coast on the night of the 30th, which did considerable damage along the San Francisco waterfront and was without warnings.

No frost warnings were issued and no damaging frosts occurred.

Southeast storm warnings were ordered at Washington and Oregon stations and later extended southward to Mendocino on the California coast. No verifying velocities were reported at coast stations. The warnings are believed to have been justified as strong gales were reported by vessels a few hundred miles off the coast.

Southeast warnings were again ordered at Washington and Oregon stations on the 22d, and continued on the 23d, and verifying velocities occurred at most stations.—*G. H. Wilson.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

No high waters occurred during the month. There were moderate local floods in the upper Trinity and lower Colorado Rivers of Texas, the former on the 5th and the latter between the 14th and 18th. Warnings for the rises were issued and no damage was done as there had been ample time to remove livestock from the lowlands. Flood stages were not quite reached, except in the Trinity River at Dallas, Tex., where the crest stage on November 18 was 1.5 feet above the flood stage of 25 feet.

Unusually low water prevailed in the Mississippi River north of Lake Pepin, and at St. Paul, Minn., on November 12 the stage was 1.3 feet below zero, or 0.3 foot lower than the previous low record of December 7, 1912. At Fort Ripley, Minn., the low-water record of 2.8 feet on October 20, 1918, was again reached on November 29.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
WEST GULF DRAINAGE.					
Trinity:					
Dallas, Tex.	*Feet.* 25	17	18	*Feet.* 26.5	18

MEAN LAKE LEVELS DURING NOVEMBER, 1923.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., December 6, 1923.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.[1]			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during November, 1923:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.03	579.06	571.02	244.34
Above or below—				
Mean stage of October, 1923	−0.03	−0.32	−0.23	−0.31
Mean stage of November, 1922	−0.23	−0.52	−0.40	−0.81
Average stage for November, last 10 years	−0.55	−1.21	−0.91	−1.25
Highest recorded November stage	−1.48	−3.86	−2.65	−3.48
Lowest recorded November stage	+0.53	−0.12	+0.32	+0.93
Average relation of the November level to—				
October level		−0.20	−0.20	−0.20
December level		+0.20	+0.20	+0.20

[1] Lake St. Clair's level: In November, 573.90 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, NOVEMBER, 1923.

By J. B. KINCER, Meteorologist.

The generally mild, pleasant weather, with light to moderate rainfall in most sections of the country during November gave favorable weather for seasonal farming operations and for growing crops. At the beginning of the month killing frost had not occurred in the Middle Atlantic Coast States south of New York nor in the Gulf States, but by the 10th it had overspread practically the whole of South Carolina and Georgia and also the northern portions of Alabama and Mississippi. The next killing frost in the South occurred about the 30th and overspread Arkansas and the northern portions of the west Gulf States. At the close of the month the southern portions of the Central and west Gulf States had not experienced killing frost. Frost did some damage to tender vegetation in South Carolina, Alabama, northern Florida, and parts of California, while some minor crops were harmed in southern New Mexico at the close of the month, but in general no material damage resulted from cold weather.

Winter wheat did well in nearly all sections of the country and at the close of the month this crop was reported quite generally as in good condition to enter the winter. Seeding in the extreme southern Great Plains was further interrupted by too much rain during the early part of the month, but after the first week better conditions prevailed and much wheat was sown. Rainfall during the first half favorably affected winter wheat in the middle Atlantic area, while the increased moisture the latter part of the month in the east Gulf States, where drought had prevailed, was very beneficial to winter cereals.

Wet weather in the southern Plains during the first part of November was unfavorable for husking and cribbing corn, with considerable complaint in Oklahoma of grain molding and rotting in the fields. Husking made rather slow progress in Iowa also, due to the snow near the close of October and the high moisture content of the grain. During the week ending November 13, and thereafter, however, much better drying weather prevailed in both the Great Plains and upper Mississippi

Valley districts and husking and cribbing made good advance.

The early part of the month was unfavorable for gathering cotton in the western portion of the Cotton Belt, because of frequent rain and muddy fields, while ungathered cotton was further damaged from too much mositure, particularly in Oklahoma and Arkansas. The middle and latter parts of the month had better weather for this work and good progress was made generally in gathering the remnants of the cotton crop.

Much of November was too dry for truck crops in the east Gulf section, but conditions were favorable in the west Gulf area and were also better the latter part of the month in the Southeast by reason of increased moisture. Unfavorable conditions prevailed for sugar cane in Louisiana where cooler weather was needed for increasing the sugar content. Considerable grinding was done, but yields were reported short.

November was favorable for stock interests in nearly all sections of the country. Unusually heavy rains for the season fell over much of the major grazing areas of the far Southwest during the second week of the month, which greatly benefited the winter range and replenished the water supply, while generally mild weather was favorable for stock. At the close of the month the lower ranges were still open in northern mountain sections. Pastures were short in Colorado and also in much of the east Gulf area because of dryness, but improvement was reported from the latter section toward the close of the month.

CLIMATOLOGICAL TABLES.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, November, 1923.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	52.2	−2.0	3 stations	80	[2] 12	Valley Head	22	17	5.22	+2.07	Healing Springs	8.20	Alaga	2.15
Alaska														
Arizona	52.0	−0.5	2 stations	89	[2] 1	Springerville	0	28	2.25	+1.22	Santa Margarita	5.60	Walnut Creek	0.07
Arkansas	50.8	−0.7	Calico Rock	81	10	2 stations	21	6	3.34	−0.23	Gravette	6.11	Whitecliffs	0.65
California	55.6	+2.8	2 stations	89	[2] 3	Weaverville	13	25	0.69	−1.91	Branscomb	4.40	12 stations	0.00
Colorado	35.5	+0.2	Lamar	78	24	Dillon	−14	28	0.66	−0.23	Rico	2.49	2 stations	T.
Florida	62.4	−3.1	Fort Lauderdale	89	1	Quincy	27	11	0.81	−1.68	Blufl Springs	5.26	Isleworth	0.00
Georgia	52.4	−2.3	Bainbridge	83	5	Blue Ridge	17	18	2.99	+0.34	Clayton	6.55	2 stations	0.39
Hawaii	71.8	+0.1	2 stations	89	[2] 7	Volcano Observatory	50	[2] 13	4.50	−4.57	Honomu	27.81	6 stations	0.00
Idaho	37.8	+2.1	Weiser	68	8	Stanley	−6	18	1.33	−0.77	Bungalow Ranger Sta.	5.32	American Falls	T.
Illinois	43.8	+1.9	2 stations	78	11	Mount Carroll	15	22	1.83	−0.57	Mount Carmel	3.60	Freeport	0.87
Indiana	43.2	+1.1	Rome	75	11	Marengo	16	1	2.29	−0.77	Huntingburg	4.85	Noblesville	0.45
Iowa	40.1	+5.1	2 stations	72	10	Decorah	9	22	0.58	−0.93	Ottumwa	1.84	Algona	0.00
Kansas	45.2	+0.9	3 stations	77	[2] 13	Richfield	0	29	0.91	−0.27	Columbus	3.09	Atwood	0.05
Kentucky	46.4	+0.3	2 stations	75	11	Farmers	16	1	3.65	+0.30	Earlington	5.88	Henderson	1.92
Louisiana	56.1	−2.8	Angola	83	22	Kelly (near)	25	18	6.38	+2.89	Houma	14.69	Plain Dealing	2.82
Maryland-Delaware	44.0	−0.4	College Park, Md	68	22	Friendsville, Md	12	20	2.63	+0.11	Public Landing, Md.	4.38	2 stations	1.65
Michigan	37.9	+1.9	2 stations	65	3	Ewen	6	22	1.11	−1.34	Owosso	2.89	St. James	0.46
Minnesota	36.2	+6.5	Faribault	75	18	Thief River Falls	3	21	0.43	−0.71	Two Harbors	1.21	2 stations	T.
Mississippi	53.5	−1.6	Leakesville	80	1	6 stations	27	[2] 10	5.12	+1.60	Fruitland Park	8.87	.....do	3.20
Missouri	45.1	+0.6	Bethany	79	10	2 stations	14	28	2.15	−0.20	Parma	4.45	Oregon	0.26
Montana	36.7	+4.6	Wheaton	73	18	Outlook	−11	30	0.79	−0.20	Haugan	4.24	Three Forks	0.00
Nebraska	41.5	+4.9	McCook	75	24	Gordon	6	1	0.38	−0.38	Atkinson	0.94	Haigler	0.00
Nevada	42.2	+1.7	Logandale	81	6	Rye Patch	3	27	0.42	−0.24	Searchlight	1.35	Las Vegas	T.
New England	38.7	+1.5	Westboro, Mass	74	6	Pittsburg, N. H	2	20	3.99	+0.63	Westboro, Mass	6.81	New Bedford, Mass	1.65
New Jersey	43.1	0.0	Little Falls	72	5	Belle Plain	11	20	2.51	−0.61	Culvers Lake	4.09	Asbury Park	1.10
New Mexico	42.1	−1.0	Carrizozo	80	12	Colmor	−12	29	1.50	+0.83	Lees Ranch	6.06	Dawson	0.29
New York	38.7	+1.2	Mount Hope	70	5	Indian Lake	7	26	3.00	+0.21	Palermo	5.12	Addison	1.26
North Carolina	48.3	−1.0	Greenville	80	21	Mount Mitchell	8	9	2.96	+0.53	Highlands	5.89	Parker	1.12
North Dakota	36.5	+9.9	Westhope	72	[2] 5	Epping	−5	30	0.50	−0.08	Lisbon	1.42	Bowman	0.04
Ohio	41.3	0.0	3 stations	70	21	2 stations	12	20	2.45	−0.12	Marietta (No. 2)	4.52	Greenville	1.15
Oklahoma	49.7	−1.0	Smithville	80	8	Kenton	1	29	2.35	+0.35	Tahlequah	6.50	Billings	0.35
Oregon	43.9	+2.5	McMinnville	80	23	Blitzen	5	27	2.29	−2.29	Headworks	9.00	Valley Falls	T.
Pennsylvania	40.7	−0.2	Greensburg	70	3	West Bingham	10	2	2.83	+0.41	Grove City	6.84	Ansonia	1.55
Porto Rico	76.9	−0.2	Mayaguez	98	3	3 stations	58	[2] 5	5.43	−1.86	Comerio Falls	12.57	Mona Island	0.70
South Carolina	51.1	−2.7	Florence (No. 1)	82	5	Santuck	21	10	2.79	+0.52	Liberty	5.70	Orangeburg	0.96
South Dakota	39.8	+6.9	Menno	79	24	Eureka	1	27	0.30	−0.24	Alexandria	0.70	Mud Butte	0.00
Tennessee	47.5	−1.0	Paris	80	12	2 stations	16	[2] 1	3.15	−0.21	Chattanooga	4.88	Elizabethton	0.93
Texas	55.1	−1.9	San Benito	90	24	.....do	2	29	2.90	+0.51	Willis	9.00	Clint	0.37
Utah	38.5	+1.0	2 stations	75	[2] 3	Koosharem	3	28	0.69	−0.28	Ogden	2.58	4 stations	0.00
Virginia	44.9	−1.3	Stuart	78	12	Wise	12	1	2.64	+0.30	Onley	4.25	Speers Ferry	0.75
Washington	42.0	+1.9	2 stations	70	[2] 5	2 stations	12	30	2.59	−2.07	2 stations	12.60	Wahluke	T.
West Virginia	42.3	−0.4	Moundsville	73	3	Cheat Bridge	10	10	3.49	+0.84	Smithfield	5.35	Beckley	1.70
Wisconsin	37.4	+3.9	Richland Center	72	11	Long Lake	1	22	0.74	−1.09	Port Washington	1.63	2 stations	0.03
Wyoming	33.9	+2.2	3 stations	68	[2] 17	Foxpark	−12	3	0.45	−0.16	Thermopolis	1.22	Elk Mountain	T.

[1] For description of tables and charts, see REVIEW, July, 1922, pp. 384-385.

[2] Other dates also.

TABLE I.—*Climatological data for Weather Bureau Stations, November, 1923.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.										
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Total.	Departure from normal.	Days with 0.01, or more.	Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F.		° F.	° F.		° F.	° F.	° F.	° F.	%	In.	In.		Miles.								0–10	In.	In.
New England.							41.2	+ 1.9										78	3.42	−0.1										6.1		
Eastport	76	67	85	29.97	30.06	+0.05	40.4	+3.7	56	3	46	15	20	35	24	38	34	80	2.27	−1.8	11	8,230	nw.	39	e.	24	9	2	19	6.9	1.3	0.0
Greenville, Me	1,070	6	......	28.87	36.06	......	34.8	......	57	4	43	11	20	27	35	......	......	......	3.39	......	9	......	......	......	......	......	12	5	13	......	T.	0.0
Portland, Me	103	82	117	29.96	30.08	+.07	40.5	+2.5	60	5	48	22	20	33	27	36	31	73	2.68	−1.1	8	6,179	n.	40	se.	30	13	6	11	5.1	0.6	0.0
Concord	288	70	79	29.74	30.06	.00	38.4	+0.8	66	5	49	14	20	28	43	......	......	......	6.10	+2.7	8	2,844	nw.	22	sw.	21	11	7	12	5.7	T.	0.0
Burlington	404	11	48	29.61	30.06	+.01	37.0	+3.2	63	4	44	18	19	30	34	......	......	......	3.20	+0.6	12	8,026	s.	50	sw.	51	3	7	20	7.8	7.6	T.
Northfield	876	12	60	29.10	30.08	+.03	34.1	+2.1	65	5	44	11	20	24	45	31	29	86	3.93	+1.3	10	4,286	s.	27	se.	21	5	8	17	7.0	10.7	1.6
Boston	125	115	188	29.92	30.06	+.01	44.6	+2.6	62	21	52	28	19	38	24	40	34	70	2.78	−1.3	7	6,526	w.	31	se.	24	9	8	13	5.8	T.	0.0
Nantucket	12	14	90	30.04	30.05	.00	45.0	−0.2	56	21	50	30	20	40	16	42	39	83	2.38	−0.9	13	11,210	ne.	44	sw.	7	8	8	14	6.0	0.0	0.0
Block Island	26	11	46	30.02	30.04	−.02	45.0	+0.4	59	5	50	30	20	40	16	42	40	82	2.62	−1.3	9	12,695	nw.	50	w.	25	10	4	16	6.1	0.0	0.0
Providence	160	215	251	29.89	30.07	.00	42.5	+2.1	64	5	50	25	20	35	27	39	36	79	3.62	−0.3	9	8,296	nw.	44	s.	30	13	5	12	5.3	T.	0.0
Hartford	159	122	140	29.89	30.07	−.01	42.2	+2.7	67	5	51	23	29	34	35	37	33	75	4.32	+0.5	9	4,817	nw.	28	nw.	25	9	6	15	6.1	T.	0.0
New Haven	106	74	153	29.95	30.07	.00	43.0	+1.0	65	4	51	25	20	35	32	39	34	74	3.75	+0.2	9	6,133	ne.	33	nw.	24	13	8	9	4.8	0.0	0.0
Middle Atlantic States.							44.6	+0.1										76	2.24	−0.6										5.8		
Albany	97	102	115	29.97	30.08	.00	39.9	+0.6	62	5	47	23	26	32	35	36	33	80	4.42	+1.6	11	4,573	s.	27	s.	21	10	8	12	5.8	9.5	T.
Binghamton	871	10	84	29.10	30.05	−.04	39.9	+2.4	61	4	47	22	19	33	32	......	......	......	1.59	−0.7	12	4,120	nw.	24	nw.	25	5	6	19	7.4	0.2	0.0
New York	314	414	454	29.73	30.08	−.01	45.4	+1.2	65	5	52	29	20	39	19	40	36	74	2.26	−1.2	7	11,379	nw.	56	se.	30	7	12	11	6.0	0.0	0.0
Harrisburg	374	94	104	29.70	30.11	.00	42.6	+0.9	59	22	49	27	20	36	24	38	32	71	1.95	−0.4	9	4,335	nw.	27	n.	11	12	4	14	5.3	T.	0.0
Philadelphia	114	123	190	29.96	30.09	−.01	46.4	+0.7	64	5	53	31	20	40	21	41	35	66	1.91	−1.2	9	7,034	n.	31	n.	24	10	7	13	5.5	0.0	0.0
Reading	325	81	98	29.73	30.09	......	43.7	......	61	30	51	26	29	37	27	41	39	87	2.21	−0.9	10	4,173	nw.	24	ne.	12	11	8	11	5.7	0.0	0.0
Scranton	805	111	119	29.21	30.09	.00	41.4	+2.3	62	4	48	23	20	34	31	37	34	79	2.20	−0.1	10	4,877	sw.	24	sw.	25	7	8	15	6.6	T.	0.0
Atlantic City	52	37	172	30.02	30.08	−.02	46.0	+0.4	63	5	52	28	9	40	23	43	39	78	2.56	−0.7	6	12,287	nw.	60	ne.	12	11	5	14	5.5	0.0	0.0
Cape May	17	13	49	30.09	30.11	+.01	46.3	−1.1	62	5	52	29	20	40	24	42	39	80	2.37	−0.8	7	5,973	ne.	40	ne.	12	8	7	15	6.2	0.0	0.0
Sandy Hook	22	10	55	30.05	30.07	......	45.6	......	60	5	50	32	20	41	15	41	37	74	1.80	......	6	11,098	w.	44	ne.	12	10	9	11	5.6	0.0	0.0
Trenton	190	159	183	29.87	30.08	......	44.0	......	63	5	52	27	20	36	27	40	35	76	2.09	−1.3	7	8,054	nw.	37	nw.	25	9	9	12	5.6	T.	0.0
Baltimore	123	100	113	29.95	30.08	−.03	46.4	+0.1	66	21	53	32	20	40	26	41	36	72	2.04	−0.9	9	3,924	n.	23	ne.	12	10	8	12	5.6	0.0	0.0
Washington	112	62	85	29.98	30.10	−.02	45.1	−0.1	64	22	53	28	10	38	30	40	35	75	2.04	−0.7	8	4,569	nw.	36	n.	24	10	8	12	5.8	T.	0.0
Cape Henry	18	8	54	30.05	30.07	......	51.0	......	69	30	56	34	18	46	30	47	44	81	2.03	−0.7	6	11,642	n.	48	ne.	13	9	7	14	6.1	T.	0.0
Lynchburg	681	153	188	29.34	30.10	−.03	46.1	−1.1	69	21	56	26	2	37	37	40	36	76	1.98	−0.8	11	5,132	ne.	32	n.	24	9	8	13	5.7	0.0	0.0
Norfolk	91	170	205	29.99	30.09	−.02	50.6	−0.8	70	21	57	33	18	44	28	46	41	76	1.95	−0.8	8	9,581	ne.	39	w.	7	8	9	13	5.8	0.0	0.0
Richmond	144	11	52	29.94	30.10	−.02	46.8	−2.0	67	22	56	27	10	38	33	41	36	75	2.20	−0.2	10	5,437	ne.	35	sw.	7	8	14	8	5.4	0.0	0.0
Wytheville	2,304	49	55	27.69	30.12	−.01	41.4	−1.6	65	22	50	24	9	33	35	36	31	74	2.28	−0.8	10	4,693	w.	34	w.	18	12	4	14	5.7	0.1	0.0
South Atlantic States.							52.5	−2.0										74	1.84	−0.9										4.8		
Asheville	2,255	70	84	27.74	30.15	+.01	44.3	−0.8	64	22	54	24	10	35	35	38	32	69	1.83	−0.4	9	6,258	nw.	27	nw.	24	12	10	8	4.6	0.1	0.0
Charlotte	779	55	62	29.25	30.10	−.03	49.0	−1.6	70	11	58	30	10	40	33	42	36	69	3.09	+0.2	10	3,309	ne.	19	nw.	17	14	4	12	4.9	0.0	0.0
Hatteras	11	11	50	30.05	30.06	−.05	54.0	−2.3	69	5	59	40	9	49	23	51	48	81	3.94	−0.7	10	11,607	ne.	40	n.	13	11	7	12	5.2	0.0	0.0
Manteo	12	5	42	......	......	......	52.4	......	70	21	...	29	11	...	38	......	......	......	2.46	......	5	......	n.	......	......	......	13	5	12	...	0.0	0.0
Raleigh	376	103	110	29.69	30.10	−.03	49.8	−0.4	71	21	59	30	10	41	30	43	38	71	1.88	−0.5	8	5,988	n.	30	nw.	24	12	6	12	5.2	0.0	0.0
Wilmington	78	81	91	30.01	30.09	−.03	53.3	−2.7	77	5	63	30	10	44	30	48	44	79	1.74	−0.7	10	5,306	w.	25	n.	13	13	10	7	4.5	0.0	0.0
Charleston	48	11	92	30.04	30.09	−.03	55.0	−3.1	77	5	63	36	10	47	26	49	45	75	1.79	−1.1	6	7,712	ne.	32	n.	13	12	6	12	5.1	0.0	0.0
Columbia, S. C	351	41	57	29.72	30.12	.00	51.9	−1.9	70	11	61	28	10	43	35	46	42	78	1.34	−0.9	7	4,629	ne.	22	sw.	6	12	6	12	4.9	0.0	0.0
Due West	711	10	55	29.35	30.13	......	49.3	......	70	22	59	28	10	40	38	......	......	......	3.46	......	8	6,309	ne.	27	w.	6	13	8	9	4.8	0.0	0.0
Greenville, S. C	1,039	113	122	28.98	30.09	......	49.6	......	69	22	58	29	18	41	35	43	37	70	4.39	......	7	5,885	ne.	32	n.	8	16	7	7	4.0	0.0	0.0
Augusta	180	62	77	29.91	30.11	−.02	52.4	−2.1	71	12	62	30	10	42	38	46	43	80	1.98	−0.9	6	3,688	nw.	21	w.	7	16	1	13	4.8	0.0	0.0
Savannah	65	150	194	30.02	30.09	−.03	55.9	−2.6	74	4	65	33	10	47	32	48	44	73	0.77	−1.6	7	8,673	ne.	33	w.	7	14	4	12	4.8	0.0	0.0
Jacksonville	43	209	245	30.04	30.09	−.01	59.6	−2.6	78	4	68	37	10	51	29	52	47	71	0.06	−2.1	2	9,233	ne.	35	ne.	1	13	7	10	4.7	0.0	0.0
Florida Peninsula.							67.8	−3.2										76	0.43	−1.8										4.6		
Key West	22	10	64	30.02	30.04	+.02	71.6	−2.7	88	27	76	56	18	67	12	65	62	77	0.73	−1.6	2	7,075	ne.	26	n.	24	17	3	10	4.2	0.0	0.0
Miami	25	71	79	30.03	30.06	......	68.4	−3.6	81	5	76	46	18	61	26	61	57	72	0.27	−2.3	5	5,459	nw.	23	e.	10	9	11	10	5.2	0.0	0.0
Sand Key	23	39	72	30.02	30.05	+.03	71.2	......	81	5	74	60	18	69	8	66	63	77	0.50	......	5	11,315	ne.	35	ne.	10	15	7	8	4.1	0.0	0.0
Tampa	35	79	87	30.05	30.09	+.01	63.4	−3.4	80	29	72	45	10	55	26	56	53	76	0.30	−1.4	4	4,141	n.	21	e.	2	9	12	9	5.1	0.0	0.0
East Gulf States.							54.3	−1.7										74	4.26	+0.8										5.0		
Atlanta	1,174	190	216	28.86	30.12	−.01	49.8	−2.3	67	12	58	32	9	42	26	44	38	70	3.55	+0.2	9	8,662	nw.	40	nw.	23	15	1	14	4.9	0.0	0.0
Macon	370	78	87	29.71	30.12	−.01	52.0	−1.3	72	12	63	29	10	41	40	44	39	73	2.24	−0.9	6	4,370	nw.	27	nw.	23	15	1	14	4.9	0.0	0.0
Thomasville	273	49	58	29.81	30.11	−.01	56.4	−2.1	78	22	67	34	10	46	34	48	43	70	2.87	+0.2	7	3,125	ne.	16	sw.	26	12	6	12	4.9	0.0	0.0
Apalachicola	36	42	49	30.06	30.11	......	58.6	......	76	4	66	41	11	51	25	52	49	76	2.44	......	5	5,840	ne.	25	ne.	2	17	7	6	4.0	0.0	0.0
Pensacola	56	149	185	30.05	30.11	.00	58.0	−2.2	76	4	65	42	1	51	25	53	49	77	3.03	−0.7	8	9,437	n.	46	s.	3	10	6	14	5.8	0.0	0.0
Anniston	741	9	57	29.34	30.15	+.03	50.0	−1.9	72	12	61	24	10	39	40	......	......	......	4.80	+1.4	8	3,800	nw.	23	e.	3	15	4	11	4.4	0.0	0.0
Birmingham	700	11	48	29.36	30.14	+.02	52.0	−2.1	73	12	61	30	9	42	32	44	39	70	5.50	+2.1	8	4,372	nw.	32	se.	3	14	5	11	4.6	0.0	0.0
Mobile	57	125	161	30.05	30.11	+.03	57.2	−1.8	77	23	67	39	10	48	27	50	47	77	4.33	+0.6	6	6,840	nw.	39	ne.	29	9	11	10	5.6	0.0	0.0
Montgomery	223	100	112	29.88	30.14	+.02	54.2	−1.6	74	12	64	35	10	44	33	47	42	70	5.89	+2.8	9	4,430	nw.	23	nw.	23	12	7	11	5.1	0.0	0.0
Corinth	469	6	......	......	......	......	50.6	......	76	11	62	30	9	40	38	......	......	......	3.76	......	9	......	s.	......	......	......	9	12	9	......	0.0	0.0
Meridian	375	85	93	29.72	30.13	+.01	52.6	−0.6	76	21	63	31	10	42	37	46	42	78	5.53	+1.4	7	3,453	ne.	32	se.	3	11	5	14	5.1	0.0	0.0
Vicksburg	247	65	74	29.86	30.15	+.03	55.1	−1.5	74	21	65	36	10	46	27	48	43	73	4.23	+0.0	8	4,084	se.	29	w.	29	10	8	12	5.1	0.0	0.0
New Orleans	53	76	84	30.06	30.12	+.02	59.9	−1.7	76	22	68	44	30	52	26	53	49	74	4.94	+1.2	6	4,421	ne.	24	s.	28	12	8	10	5.3	0.0	0.0
West Gulf States.							55.9	−0.6										77	3.07	0.0										5.8		
Shreveport	249	77	93	29.86	30.14	+.03	55.6	+0.3	75	22	64	37	30	47	30	48	44	74	3.19	−0.9	7	3,920	s.	17	n.	26	15	5	10	4.6	0.0	0.0
Bentonville	1,303	11	44	......	......	......	48.0	+1.3	70	18	57	28	27	39	33	......	......	......	4.94	......	8	3,332	n.	......	......	......	17	3	10	......	5.1	T.
Fort Smith	457	79	94	29.62	30.11	.00	51.1	+1.2	73	20	61	31	30	41	36	45	40	73	3.96	+0.7	9	4,535	e.	29	w.	25	15	2	13	5.0	0.1	0.0
Little Rock	357	136	144	29.73	30.11	.00	52.6	+0.5	74	13	62	33	28	44	35	46	41	73	2.59	−2.0	9	5,320	s.	27	nw.	25	13	6	11	4.6	0.0	0.0
Brownsville	57	53	61	30.02	30.08	......	63.8	......	82	23	70	44	29	58	24	59	57	87	3.34	......	9	4,855	n.	24	s.	25	3	9	18	7.6	0.0	0.0
Corpus Christi	20	11	73	30.09	30.12	+.04	61.0	−2.4	79	25	70	41	29	55	19	57	[illegible]	83	2.15	−0.3	13	6,822	n.	30	ne.	27	4	6	20	7.9	0.0	0.0
Dallas	512	109	117	29.57	30.13	......	55.4	......	79	25	65	35	30	46	33	......	......	......	2.05	......	7	5,339	nw.	23	s.	25	12	7	11	5.1	0.0	0.0
Fort Worth	670	106	114	29.40	30.13	+.02	56.0	+0.9	80	25	65	36	28	47	32	49	44	70	1.63	+0.1	6	6,056	s.	26	sw.	22	17	[illegible]	11	5.2	T.	0.0
Galveston	54	106	114	30.06	30.12	+.03	60.0	−3.3	74	24	65	43	29	55	18	56	53	83	4.80	+0.1	7	7,488	n.	32	nw.	29	6	14	10	5.8	0.0	0.0
Groesbeck	461	11	56	29.63	30.12	......	55.8	......	75	24	65	37	18	47	32	......	......	......	2.44	......	6	6,337	se.	32	sw.	25	9	7	14	5.7	0.0	0.0
Houston	138	111	121	29.96	30.11	......	59.2	−2.1	74	25	69	42	28	49	30	......	......	......	3.64	......	10	5,023	n.	32	se.	11	10	7	13	6.1	0.0	0.0
Palestine	510	64	72	29.59	30.13	+.02	55.6	−1.6	74	22	64	36	6	47	32	48	44	72	2.52	−1.1	5	4,614	s.	22	s.	25	10	5	15	5.5	0.0	0.0
Port Arthur	34	58	67	30.08	30.12	......	58.0	......	79	23	65	40	7	51	25	52	49	80	3.52	......	7	5,895	nw.	27	ne.	27	7	11	12	6.2	0.0	0.0
San Antonio	693	119	132	29.38	30.12	+.04	58.7	−0.5	80	24	66	36	29	51	23	52	48	75	4.21	+2.4	9	4,892	n.	26	n.	28	7	9	14	6.1	0.0	0.0
Taylor	583	55	63	29.53	30.14	+.06	57.2	−0.5	79	24	66	37	29	48	31	......	......	......	3.25	+0.6	7	4,832	nw.	25	s.	25	9	7	14	5.9	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau Stations, November, 1923*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation. Total.	Departure from normal.	Days with 0.01, or more.	Wind. Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F	°F.			°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Ohio Valley and Tennessee.							45.6	+0.6										73	2.83	-0.6										5.8		
Chattanooga	762	189	213	29.31	30.13	-.01	49.5	-0.9	71	11	58	30	10	41	34	42	35	65	4.88	+1.3	11	5,114	nw.	27	nw.	23	13	4	13	5.0	0.0	0.0
Knoxville	996	102	111	29.04	30.11	-.02	47.6	-0.3	68	11	57	28	10	38	34	42	37	74	1.96	-1.6	7	4,002	ne.	25	sw.	30	13	7	10	4.9	0.0	0.0
Memphis	399	76	97	29.68	30.12	.00	52.6	+0.9	72	12	60	33	28	45	27	46	40	68	3.08	-1.5	7	5,452	sw.	36	sw.	29	16	3	11	4.6	0.0	0.0
Nashville	546	168	191	29.54	30.13	+.01	48.9	-0.1	72	11	58	28	10	40	36	42	37	69	2.87	-1.0	10	6,320	ne.	34	nw.	17	10	9	11	5.4	0.0	0.0
Lexington	989	193	230	29.03	30.12	.00	44.8	+0.1	66	21	52	28	28	37	29	......	......	......	2.71	-0.8	13	10,044	sw.	37	se.	29	11	3	16	5.1	T.	0.0
Louisville	525	219	255	29.53	30.12	.00	46.8	+0.1	68	11	55	29	28	39	30	40	35	68	3.02	-1.2	10	7,875	s.	41	s.	30	11	8	11	5.5	0.0	0.0
Evansville	431	139	175	29.64	30.12	.00	47.6	+2.3	70	11	56	29	28	40	29	41	36	70	3.54	-0.6	9	7,794	sw.	40	sw.	29	10	11	9	5.1	0.0	0.0
Indianapolis	822	194	230	29.20	30.10	.00	44.2	+1.9	63	11	51	30	9	37	28	39	34	72	2.04	-1.5	10	8,341	se.	35	se.	29	8	7	15	6.3	T.	0.0
Royal Center	736	11	55	29.27	30.09	......	41.0	......	61	11	49	22	1	33	30	......	......	......	1.72	......	11	6,765	se.	28	nw.	7	7	4	19	7.2	T.	0.0
Terre Haute	575	96	129	29.47	30.09	......	45.0	......	67	11	53	30	1	37	30	40	36	76	1.53	......	9	6,418	nw.	36	s.	29	9	8	13	6.0	0.0	0.0
Cincinnati	628	11	51	29.42	30.12	.00	43.8	+1.3	66	21	52	26	9	36	31	......	37	80	2.28	-0.9	10	5,206	ne.	24	sw.	21	10	5	15	6.0	T.	0.0
Columbus	824	179	222	29.21	30.10	-.00	42.4	+0.5	63	21	50	25	9	35	28	38	36	83	2.30	-0.8	11	7,147	nw.	38	nw.	7	8	6	16	6.3	T.	0.0
Dayton	899	137	173	29.12	30.10	......	42.8	+0.7	63	21	51	28	1	35	29	38	33	75	2.26	-0.6	12	6,402	sw.	29	nw.	26	9	7	14	5.8	T.	0.0
Elkins	1,947	59	67	28.02	30.14	+.02	40.9	+1.3	64	21	51	19	20	31	39	35	32	81	3.28	+0.4	13	3,930	w.	24	w.	30	8	7	15	6.6	T.	0.0
Parkersburg	638	77	84	29.45	30.12	.00	44.0	+0.8	68	21	52	25	9	36	35	38	33	72	2.97	+0.1	15	3,953	se.	24	nw.	16	11	4	15	6.3	T.	0.0
Pittsburgh	842	353	410	29.17	30.10	.00	43.2	0.0	65	21	50	29	9	36	29	38	34	74	2.39	-0.2	11	7,909	nw.	40	se.	29	6	8	16	6.9	0.2	0.0
Lower Lake Region.							40.6	+1.2										78	2.47	-0.5										7.2		
Buffalo	767	247	280	29.22	30.06	+.01	40.2	+0.8	60	3	46	25	19	35	20	37	33	77	2.74	-0.6	12	11,252	sw.	56	sw.	17	5	7	18	7.5	0.9	0.0
Canton	448	10	61	29.54	30.03	......	36.8	+2.9	67	4	43	19	9	30	35	......	......	......	3.84	+0.4	13	6,436	sw.	37	sw.	20	6	5	19	7.2	3.8	0.0
Oswego	335	76	91	......	30.05	.00	40.0	+1.1	58	4	46	25	19	34	24	......	......	......	3.30	-0.1	13	7,597	s.	26	n.	8	3	5	22	....	0.0	0.0
Rochester	523	86	102	29.48	30.07	-.02	41.0	+2.3	62	21	47	25	19	35	28	37	32	75	3.10	+0.3	14	5,481	sw.	25	w.	30	4	4	22	8.0	4.0	0.0
Syracuse	597	97	113	29.42	30.07	-.01	40.0	+1.3	60	3	46	24	19	34	25	......	......	......	1.90	-0.8	14	7,406	s.	41	s.	20	3	6	21	8.1	1.3	0.0
Erie	714	130	166	29.28	30.06	.00	41.8	+0.4	60	21	47	27	19	36	25	38	33	73	2.45	-1.2	11	10,765	s.	49	se.	30	8	3	19	7.0	0.4	0.0
Cleveland	762	190	201	29.24	30.08	+.01	42.0	+1.1	61	21	47	28	29	37	24	38	34	76	2.64	-0.1	11	9,852	s.	48	nw.	7	4	9	17	7.3	T.	0.0
Sandusky	629	62	70	29.39	30.09	+.01	41.9	+0.8	62	21	48	27	9	36	24	......	......	......	1.77	-1.0	10	5,780	sw.	28	nw.	7	4	8	18	7.1	T.	0.0
Toledo	628	208	243	29.39	30.09	+.02	41.3	+0.9	61	21	48	25	19	35	26	37	33	77	1.40	-1.2	9	9,200	sw.	36	sw.	30	9	6	15	6.2	T.	0.0
Fort Wayne	856	113	124	29.15	30.10	......	41.2	+0.6	61	10	48	26	29	34	27	37	34	80	2.06	......	9	6,039	sw.	26	nw.	16	8	7	15	6.5	T.	0.0
Detroit	730	218	258	29.26	30.08	+.02	40.4	+1.1	60	10	46	26	19	35	27	38	36	85	1.54	-1.1	9	7,367	sw.	31	sw.	10	6	6	18	6.9	0.3	0.0
Upper Lake Region.							38.7	+3.9										80	1.06	-1.4										6.8		
Alpena	609	13	92	29.37	30.05	+.04	37.4	+3.0	57	10	44	21	22	30	29	34	31	80	0.85	-1.7	11	7,756	nw.	33	sw.	20	8	5	17	6.7	0.3	0.0
Escanaba	612	54	60	29.35	30.03	.00	37.6	+5.9	60	10	44	19	22	32	24	34	30	78	1.14	-1.1	7	7,210	sw.	35	n.	7	9	3	18	6.3	0.6	T.
Grand Haven	632	54	89	29.36	30.06	+.02	39.8	+1.3	58	3	46	25	6	33	25	37	34	81	0.87	-1.7	9	8,285	n.	36	w.	26	8	3	19	6.9	0.6	0.0
Grand Rapids	707	70	87	29.29	30.08	+.03	40.4	+2.3	60	10	47	26	19	33	22	36	32	77	1.09	-1.4	8	3,926	nw.	19	nw.	16	9	1	20	6.9	0.8	0.0
Houghton	668	62	99	29.24	29.98	-.04	37.2	+5.7	58	9	44	17	22	31	31	......	......	......	1.14	-1.7	12	6,604	w.	28	w.	26	6	8	16	7.0	8.9	3.0
Lansing	878	11	62	29.10	30.06	......	38.2	+1.4	62	10	46	19	19	30	29	34	31	83	1.48	-0.9	9	4,254	s.	20	sw.	20	8	5	17	6.6	T.	0.0
Ludington	637	60	66	29.34	30.05	......	39.8	......	54	3	45	28	22	35	18	37	34	81	0.89	......	12	7,940	n.	34	s.	20	7	5	18	6.3	1.7	0.0
Marquette	734	77	111	29.21	30.02	.00	38.2	+6.3	57	1	45	19	28	32	32	33	29	74	1.22	-1.6	11	6,595	s.	41	sw.	2	6	6	18	7.3	1.5	T.
Port Huron	638	70	120	29.35	30.06	+.01	38.8	+1.3	58	3	45	21	19	33	25	36	33	81	1.60	-1.1	9	8,036	nw.	36	n.	7	7	6	17	6.8	T.	0.0
Saginaw	641	69	77	29.36	30.07	......	37.6	......	62	10	45	21	19	30	27	35	34	88	1.14	-1.2	9	5,936	sw.	30	sw.	20	8	5	17	6.7	T.	0.0
Sault Sainte Marie	614	11	52	29.32	30.03	+.02	36.2	+5.5	56	3	42	19	18	30	27	33	30	83	1.04	-1.9	11	5,630	se.	30	sw.	20	5	5	20	7.8	2.4	0.0
Chicago	823	140	310	29.19	30.09	+.02	43.8	+2.6	62	10	49	31	22	38	24	40	37	76	1.46	-1.0	7	8,354	nw.	32	s.	20	8	5	17	6.6	T.	0.0
Green Bay	617	109	144	29.36	30.03	-.01	38.6	+6.1	60	10	46	19	22	32	31	34	30	77	0.60	-1.4	6	8,244	s.	34	s.	20	6	5	19	7.3	T.	0.0
Milwaukee	681	125	139	29.31	30.06	+.01	40.9	+3.6	61	10	47	26	28	35	26	37	33	77	0.71	-1.3	8	7,139	w.	30	e.	29	8	5	17	6.7	T.	0.0
Duluth	1,133	11	47	28.76	30.00	-.04	35.8	+5.8	60	11	44	16	8	28	27	31	28	81	0.63	-1.0	6	9,862	sw.	49	nw.	25	11	4	15	5.8	3.3	0.0
North Dakota.							36.9	+10.6										74	0.46	-0.3										5.6		
Moorhead	940	50	58	28.96	30.00	-.07	35.8	+8.7	60	9	45	10	21	27	40	31	26	72	0.30	-0.7	7	3,711	s.	27	nw.	25	15	2	13	5.0	1.0	0.3
Bismarck	1,674	8	57	28.23	30.06	-.01	38.8	+10.3	63	2	50	8	27	27	36	32	28	74	0.29	-0.4	4	5,774	nw.	35	n.	25	10	8	12	5.4	T.	T.
Devils Lake	1,478	11	44	28.37	29.99	-.07	35.6	+13.0	61	8	45	9	27	26	36	30	26	77	0.47	-0.2	6	6,610	sw.	32	nw.	25	12	6	12	5.4	0.2	T.
Ellendale	1,457	10	56	28.43	30.02	......	37.5	......	64	9	49	13	21	26	41	......	......	......	0.23	......	3	9,122	nw.	46	nw.	25	9	7	14	6.0	T.	T.
Grand Forks	835	12	89	......	......	......	35.6	......	66	8	46	7	21	25	54	......	......	......	0.65	......	8	......	s.	30	nw.	25	7	13	10	....	0.7	0.2
Williston	1,878	41	48	27.98	30.00	-.06	37.4	+10.2	64	8	48	11	30	27	40	32	27	74	0.78	+0.2	7	5,123	sw.	34	w.	24	7	7	16	6.4	0.3	0.3
Upper Mississippi Valley.							42.3	+3.4										75	1.17	-0.8										5.5		
Minneapolis	918	102	208	29.02	30.01	......	39.4	......	61	11	47	20	22	32	27	......	......	......	0.45	-0.7	5	8,297	nw.	38	nw.	25	12	6	12	5.4	1.4	0.0
St. Paul	837	236	261	29.12	30.04	-.02	38.3	+5.8	60	11	47	16	22	30	29	......	......	......	0.35	-1.0	4	9,262	sw.	47	nw.	25	11	8	11	5.2	1.2	0.0
La Crosse	714	11	48	29.27	30.06	-.01	39.2	+4.0	63	10	49	14	22	30	36	......	......	......	0.39	-1.1	5	3,995	se.	19	sw.	25	10	8	12	5.8	0.7	0.0
Madison	974	70	78	29.01	30.09	+.03	38.9	+3.7	61	10	45	23	28	32	24	35	31	77	0.68	-1.1	7	6,265	nw	28	sw.	20	8	7	15	6.5	0.2	0.0
Wausau	1,247	4	......	28.69	30.06	......	34.9	......	57	10	42	13	22	28	33	......	......	......	0.77	......	6	......	nw.	......	......	......	9	5	16	6.1	5.4	0.3
Charles City	1,015	10	49	28.98	30.09	+.01	37.9	+4.9	62	10	48	15	22	28	36	32	29	79	0.33	-1.1	2	4,583	nw.	22	n.	16	11	10	9	4.7	1.5	0.0
Davenport	606	71	79	29.42	30.09	+.01	42.0	+3.0	68	10	50	25	22	34	29	37	33	76	1.02	-0.7	8	4,552	nw.	22	nw.	25	12	4	14	6.0	T.	0.0
Des Moines	861	84	97	29.16	30.09	+.01	42.2	+3.8	67	10	52	22	22	32	36	38	34	79	0.55	-0.9	3	24,570	nw.	22	sw.	1	12	10	8	4.7	0.3	0.0
Dubuque	698	81	96	29.33	30.10	+.01	40.0	+3.0	65	10	48	18	22	32	32	35	30	73	1.19	-0.6	8	4,236	nw.	23	nw.	26	6	11	13	6.7	3.0	0.8
Keokuk	614	64	78	29.42	30.11	+.02	43.6	+2.5	70	10	52	26	27	35	32	38	33	72	1.26	-0.6	8	4,734	s.	22	w.	25	11	8	11	5.5	3.7	T.
Cairo	358	87	93	29.71	30.11	-.01	49.1	+1.8	72	12	57	29	28	41	28	42	37	69	3.59	-0.4	7	5,776	n.	36	sw.	29	10	7	13	5.5	0.0	0.0
Peoria	609	11	45	29.43	30.11	+.02	42.2	+4.7	67	10	50	24	1	34	31	37	34	81	1.37	-1.3	8	3,996	nw.	19	sw.	20	12	8	10	5.3	T.	0.0
Springfield, Ill	636	10	91	29.39	30.08	-.02	44.2	+2.0	66	10	51	30	1	37	28	39	35	78	1.44	-1.2	9	5,575	s.	23	nw.	23	11	6	13	5.5	0.0	0.0
Hannibal	534	74	109	29.52	30.11	+.02	44.6	+2.5	71	10	53	24	9	36	33	......	......	......	1.91	0.0	9	5,384	sw.	24	sw.	20	12	6	12	5.1	1.2	T.
St. Louis	568	265	303	29.48	30.10	.00	47.9	+2.8	70	10	55	30	27	41	27	41	36	69	1.90	-1.0	6	8,580	nw.	42	sw.	29	12	7	11	4.9	T.	0.0
Missouri Valley.							43.8	+5.5										69	0.90	-0.3										4.2		
Columbia, Mo.	784	11	84	29.26	30.10	+.01	45.4	+3.0	72	10	55	23	27	36	31	......	......	......	1.35	-1.0	7	5,158	se.	26	nw.	23	13	6	11	4.9	0.8	0.0
Kansas City	963	161	181	29.06	30.11	+.02	47.0	+5.5	71	10	55	24	28	39	29	40	34	67	1.66	-0.2	4	7,105	nw.	30	nw.	16	14	7	9	4.5	9.1	6.5
St. Joseph	967	11	49	29.04	30.10	......	45.0	......	69	11	54	20	28	36	32	39	34	72	0.68	......	4	4,954	nw.	26	nw.	25	18	3	9	3.8	2.3	T.
Springfield, Mo.	1,324	98	104	28.68	30.11	+.01	47.0	+2.6	68	20	55	24	28	39	26	41	36	73	3.47	+0.8	9	6,565	nw.	27	s.	20	16	4	10	4.5	2.6	0.0
Iola	984	11	50	29.05	30.12	+.03	47.2	+4.2	72	10	58	26	30	37	35	......	......	......	1.59	+0.2	4	3,980	n.	24	n.	16	11	10	9	4.2	7.3	4.0
Topeka	987	92	107	......	......	......	45.7	+4.0	73	10	55	24	28	36	35	......	......	......	0.81	-0.4	5	5,912	s.	32	n.	16	19	3	8	3.7	2.0	0.0
Drexel	1,299	10	54	28.67	30.09	......	41.1	......	64	10	52	17	28	30	34	......	......	......	0.30	......	3	6,664	s.	28	nw.	25	14	8	8	4.5	T.	0.0
Lincoln	1,189	11	84	28.81	30.11	+.03	43.2	+5.2	67	9	54	19	28	32	41	37	31	69	0.20	-0.6	2	5,710	s.	37	nw.	25	12	9	9	4.6	0.0	0.0
Omaha	1,105	115	122	28.90	30.10	+.02	43.8	+5.3	65	11	53	21	28	35	30	38	32	69	0.27	-0.8	3	4,693	nw.	28	nw.	25	16	10	4	3.8	T.	0.0
Valentine	2,598	47	54	27.31	30.08	.00	41.7	+7.1	70	24	55	20	27	28	40	33	27	66	0.28	-0.4	2	6,142	w.	35	nw.	25	17	11	2	3.0	0.0	0.0
Sioux City	1,135	94	164	28.86	30.10	+.02	40.8	+5.6	67	17	50	20	28	31	35	35	30	71	0.32	-0.6	2	7,409	s.	41	nw.	25	14	9	7	4.4	T.	0.0
Huron	1,306	59	74	28.65	30.08	.00	39.2	+7.7	70	24	51	16	27	27	43	33	27	69	0.31	-0.3	2	6,117	nw.	34	w.	25	11	16	3	4.0	T.	0.0
Pierre	1,572	70	75	28.36	830.05	-.03	42.6	+9.0	72	24	55	13	27	30	40	35	29	67	0.20	-0.2	2	5,433	nw.	44	nw.	25	16	8	6	3.7	0.0	0.0
Yankton	1,233	49	57	28.74	30.09	+.01	41.7	+6.3	70	24	53	18	27	31	37	......	......	......	0.32	-0.5	2	4,725	w.	36	nw.	25	12	11	7	4.8	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau Stations, November, 1923*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation. Total.	Departure from normal.	Days with 0.01, or more.	Wind. Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F		° F	° F.			° F.	° F.	° F.	%	In.	In.		Miles.								0-10	In.	In.
Northern Slope.							36.5	+4.3										69	0.49	−0.3										4.7		
Billings	3,140	5	.....			.....	39.6	.....	67	24	53	14	23	26	42				0.02		1		sw.				15	9	6	....	T.	0.0
Havre	2,505	11	44	27.35	30.03	.00	37.8	+6.6	62	16	52	7	30	24	43	32	27	70	0.17	−0.6	3	5,538	sw.	48	w.	24	14	3	13	5.3	1.6	1.4
Helena	4,110	87	112	25.86	30.14	+.04	38.1	+4.9	56	24	48	16	30	28	32	31	25	64	0.65	−0.1	5	5,189	sw.	37	sw.	24	10	9	11	5.5	3.2	0.6
Kalispell	2,973	48	56	27.04	30.17	+.10	33.7	+1.7	49	4	39	18	30	28	26	32	28	83	0.89	−1.0	8	2,703	nw.	35	sw.	24	3	8	19	7.7	1.3	0.0
Miles City	2,371	48	55	27.52	30.12	+.05	40.8	+9.9	63	8	52	13	20	30	37	34	29	70	0.80	+0.2	4	3,482	s.	30	nw.	30	13	8	9	4.8	1.4	T.
Rapid City	3,259	50	58	26.64	30.11	+.03	43.0	+9.4	69	24	55	24	27	31	36	34	27	59	0.06	−0.4	2	5,811	w.	34	nw.	25	15	9	6	3.9	0.4	0.0
Cheyenne	6,088	84	101	24.05	30.14	+.07	37.4	+2.5	59	18	47	19	28	27	29	31	26	67	0.28	−0.1	4	9,099	w.	48	w.	24	17	8	5	3.4	0.4	T.
Lander	5,372	60	68	24.73	30.30	+.20	23.0	−5.7	57	24	33	−6	1	13	32	19	14	74	0.65	0.0	3	1,932	sw.	28	nw.	24	14	8	8	4.2	5.0	2.5
Sheridan	3,790	10	47	26.15	30.13	.....	38.4	.....	68	17	52	12	1	25	47	31	26	70	0.36	.....	6	3,372	nw.	37	nw.	24	13	9	8	4.7	1.7	0.2
Yellowstone Park	6,200	11	48	23.96	30.23	+.12	32.4	+3.1	55	7	43	9	27	21	32	26	21	67	0.48	−1.0	9	5,017	s.	37	s.	24	14	5	11	4.7	4.4	2.0
North Platte	2,821	11	51	27.16	30.15	+.07	42.5	+5.9	71	24	56	18	29	29	39	33	27	68	0.45	0.0	1	4,099	w.	31	nw.	25	18	8	4	3.2	T.	0.0
Middle Slope.							45.1	+2.9										68	0.90	0.0										4.0		
Denver	5,292	106	113	24.79	30.13	+.07	41.8	+2.0	70	17	53	17	28	30	38	34	25	57	0.24	−0.3	3	5,011	s.	42	w.	20	17	10	3	3.5	2.0	T.
Pueblo	4,685	80	86	25.35	30.12	+.07	41.3	+2.0	73	24	56	7	28	26	51	32	24	60	0.66	+0.3	1	3,833	nw.	32	nw.	24	17	10	3	3.5	7.4	3.8
Concordia	1,392	50	58	28.61	30.12	+.04	44.9	+5.0	70	10	56	20	28	34	38	38	32	71	0.61	−0.3	5	4,378	s.	24	s.	11	13	7	10	4.7	T.	0.0
Dodge City	2,509	11	51	27.50	30.15	+.08	45.2	+2.6	70	10	58	23	29	33	39	37	32	74	0.53	0.0	3	5,441	nw.	28	s.	11	17	6	7	3.6	T.	0.0
Wichita	1,358	139	158	28.64	30.10	+.02	47.3	+3.5	66	18	56	30	30	39	31	41	36	72	1.26	+0.1	6	7,536	s.	38	sw.	24	15	7	8	4.3	1.8	T.
Broken Arrow	765	11	52	29.28	30.12	.....	50.2	.....	72	20	59	31	30	41	30	....	....	....	4.28	.....	8	7,688	s.	37	s.	20	12	9	9	4.5	3.8	0.0
Muskogee	652	4	.....	.....	.....	.....	51.4	.....	74	20	63	30	30	40	39	....	....	....	4.89	.....	9	.....	e.	....	....	....	15	5	10	....	2.5	0.0
Oklahoma City	1,214	10	47	28.82	30.13	+.05	50.2	+2.3	70	20	59	32	6	42	30	44	40	76	2.13	−0.1	5	6,049	n.	26	sw.	20	16	5	9	4.1	T.	0.0
Southern Slope.							50.5	−0.4										74	2.35	+1.2										4.9		
Abilene	1,738	10	52	28.29	30.12	+.05	52.2	−0.4	75	25	62	32	29	43	34	46	43	79	2.09	+0.8	9	5,453	s.	29	s.	11	12	1	17	5.9	0.3	0.0
Amarillo	3,676	10	49	26.35	30.13	+.08	45.4	+1.6	72	24	56	14	29	35	37	38	34	75	2.13	+1.0	7	5,923	n.	33	n.	25	18	7	5	3.8	11.0	2.9
Del Rio	944	64	71	29.10	30.11	+.06	57.8	−1.5	77	23	65	33	29	50	27	....	....	....	4.13	+2.9	9	4,673	se.	24	se.	2	7	8	15	6.1	0.0	0.0
Roswell	3,566	75	85	26.44	30.09	+.06	46.6	−1.5	77	24	59	15	29	34	49	39	32	67	1.05	+0.2	5	4,083	n.	32	e.	27	16	9	5	3.8	3.8	0.0
Southern Plateau.							49.7	+0.6										62	0.95	+0.4										3.1		
El Paso	3,762	110	133	26.25	30.05	+.05	51.2	+0.3	70	25	60	30	30	42	34	43	36	60	0.53	−0.1	6	7,431	nw.	38	w.	27	13	10	7	4.3	0.0	0.0
Santa Fe	7,013	57	66	23.28	30.11	+.08	38.8	−0.1	58	24	49	15	28	29	29	30	23	59	0.82	0.0	5	4,126	e.	29	se.	10	18	5	7	3.4	2.2	T.
Flagstaff	6,907	10	59	23.37	30.03	+.01	37.6	+3.0	62	24	49	13	28	26	38	....	....	68	2.36	.....	6	5,475	e.	46	ne.	27	14	11	5	....	4.7	0.0
Phoenix	1,108	11	81	28.84	30.01	+.10	59.1	+0.4	80	9	71	37	29	47	34	50	44	65	2.84	+1.9	5	3,473	e.	24	e.	4	19	3	8	3.4	0.0	0.0
Yuma	141	9	54	29.84	29.99	+.01	62.4	0.0	80	3	75	37	29	50	38	52	43	54	0.27	0.0	3	2,273	n.	32	n.	26	22	5	3	2.5	0.0	0.0
Independence	3,957	5	25	26.08	30.16	+.11	49.2	0.0	70	5	64	26	28	35	40	39	30	66	0.27	0.0	1	4,626	nw.	41	nw.	26	24	5	1	1.7	0.0	0.0
Middle Plateau.							41.3	+1.4										59	0.72	−0.2										3.4		
Reno	4,532	74	81	25.57	30.16	+.05	43.6	+2.6	66	24	58	19	27	29	40	35	25	55	0.01	−1.1	1	3,022	w.	28	sw.	29	18	8	4	3.2	T.	0.0
Tonopah	6,090	12	20	24.12	30.09	.....	42.3	.....	57	23	50	21	30	35	22	34	22	47	0.83	−0.1	4	4,624	w.	40	nw.	26	20	6	4	3.0	0.5	T.
Winnemucca	4,344	18	56	25.74	30.20	+.06	39.7	+1.3	66	6	56	12	27	23	43	32	24	63	0.53	−0.2	3	4,981	ne.	31	nw.	30	13	8	9	4.4	T.	T.
Modena	5,479	10	43	24.69	30.12	+.04	39.0	0.0	65	24	53	13	28	25	44	30	22	57	1.02	+0.4	4	5,961	w.	34	n.	26	18	6	6	3.2	T.	0.0
Salt Lake City	4,360	163	203	25.74	30.17	+.05	43.2	+2.1	65	24	52	26	28	35	25	34	31	64	1.05	−0.4	5	3,872	nw.	31	e.	10	19	5	6	3.4	3.8	0.0
Grand Junction	4,602	60	68	25.49	30.13	+.05	41.1	+1.2	60	6	52	20	29	30	30	34	28	66	0.85	+0.3	3	2,895	se.	18	s.	11	21	3	6	2.9	T.	0.0
Northern Plateau.							41.2	+2.1										74	0.86	−0.5										5.6		
Baker	3,471	48	53	26.58	30.23	+.07	38.6	+3.7	59	7	49	22	27	28	31	34	30	74	0.38	−0.8	5	4,413	se.	26	s.	24	11	6	13	5.5	T.	0.0
Boise	2,739	78	86	27.32	30.22	+.05	42.6	+1.6	61	24	53	23	27	32	28	38	32	67	0.55	−0.3	5	2,350	se.	29	w.	24	14	8	8	4.5	T.	T.
Lewiston	757	40	48	29.37	30.20	+.08	42.1	+1.2	61	2	51	24	11	33	31	....	....	....	1.78	+0.5	8	1,696	e.	25	w.	24	7	6	17	6.5	0.0	0.0
Pocatello	4,477	60	68	25.59	30.18	+.04	40.0	+3.7	60	10	51	18	27	29	31	34	30	72	0.38	−0.2	4	5,088	se.	28	sw.	24	13	9	8	4.6	0.4	0.2
Spokane	1,929	101	110	28.10	30.20	+.10	39.0	+0.5	57	2	46	25	27	32	26	37	34	82	0.87	−1.4	9	3,763	sw.	28	sw.	24	7	10	13	6.5	1.3	T.
Walla Walla	991	57	65	29.10	30.19	+.06	44.8	+1.9	65	23	51	30	11	38	21	41	37	77	1.18	−1.0	9	2,791	s.	28	w.	24	9	8	13	6.0	T.	0.0
North Pacific Coast Region.							49.2	+3.4										85	3.14	−3.7										6.9		
North Head	211	11	56	29.87	30.10	+.05	52.8	+5.1	70	5	57	40	30	48	22	49	45	78	3.36	−3.0	16	10,513	se.	66	s.	23	9	8	13	5.7	0.0	0.0
Port Angeles	29	8	53	.....	30.10	.....	44.8	.....	58	13	50	33	30	39	17	....	....	....	1.54	−2.9	13	3,614	s.	29	w.	29	2	7	21	....	0.0	0.0
Seattle	125	215	250	30.00	30.13	+.09	47.4	+2.9	62	3	52	36	30	43	17	45	43	86	2.06	−3.8	12	5,334	se.	44	sw.	23	2	8	20	7.8	0.0	0.0
Tacoma	213	113	120	29.90	30.12	+.08	46.4	+2.3	62	3	52	32	18	41	23	....	....	....	1.85	−6.7	12	2,970	s.	17	n.	30	1	6	23	8.5	0.0	0.0
Tatoosh Island	86	9	57	29.96	30.06	+.08	49.0	+3.3	59	4	52	41	30	46	11	48	47	95	7.05	−5.0	18	16,395	se.	54	sw.	24	7	4	19	7.2	0.0	0.0
Yakima	1,071	5																														
Medford	1,425	4	.....	.....	.....	.....	45.4	.....	68	4	57	26	27	34	38	48	41	89	0.87	.....	8	.....	se.	....	....	....	11	4	15	....	0.0	0.0
Portland, Oreg	153	68	106	29.98	30.14	+.04	50.4	+3.6	67	5	57	32	18	44	24	46	43	78	4.15	−2.3	14	3,548	se.	26	w.	24	8	4	18	6.3	0.0	0.0
Roseburg	510	9	57	29.60	30.16	+.04	49.2	+3.3	64	7	57	31	30	42	26	47	45	86	1.95	−2.4	8	1,300	n.	14	sw.	24	4	16	10	6.1	0.0	0.0
Middle Pacific Coast Region.							57.8	+4.2										68	0.97	−2.1										3.5		
Eureka	62	73	89	30.06	30.13	+.02	53.6	+2.6	71	6	61	38	5	46	25	50	47	82	2.86	−2.8	5	3,479	se.	35	n.	30	12	7	11	5.3	0.0	0.0
Point Reyes	490	7	18	29.52	30.04	.....	58.8	+5.8	77	6	64	47	4	53	23	....	....	....	0.37	.....	5	10,916	n.	58	nw.	30	12	10	8	4.4	0.0	0.0
Red Bluff	332	50	56	29.73	30.09	−.02	57.4	+3.5	81	4	70	38	18	45	36	49	39	56	0.57	−2.6	4	3,387	nw.	33	n.	30	19	7	4	2.8	0.0	0.0
Sacramento	69	106	117	30.00	30.06	−.03	58.5	+4.9	80	15	70	41	1	47	32	51	44	62	0.62	−1.5	3	3,897	n.	40	nw.	30	23	4	3	2.2	0.0	0.0
San Francisco	155	208	243	29.90	30.07	−.02	60.8	+4.5	78	15	68	51	25	54	24	53	48	71	0.49	−2.0	2	4,138	w.	58	n.	30	18	8	4	3.3	0.0	0.0
San Jose	141	12	110	29.91	30.07	.....	57.5	+3.1	81	5	72	38	4	43	41	....	....	....	0.30	−1.6	4	3,474	s.	30	nw.	30	18	7	5	3.3	0.0	0.0
South Pacific Coast Region.							62.8	+4.9										56	0.16	−1.1										2.3		
Fresno	327	89	98	29.71	30.07	+.01	68.2	+3.6	80	6	71	41	1	46	30	49	40	56	0.10	−0.9	1	2,366	nw.	14	nw.	30	23	3	4	1.9	0.0	0.0
Los Angeles	338	159	191	29.65	30.01	−.01	66.4	+5.5	84	5	76	51	1	57	27	53	44	52	0.04	−1.4	1	3,840	ne.	19	se.	16	22	5	3	2.2	0.0	0.0
San Diego	87	62	70	29.89	29.98	−.04	64.0	+4.3	84	4	73	47	29	55	30	54	48	60	0.16	−0.7	2	3,535	nw.	26	e.	16	19	8	3	2.8	0.0	0.0
San Luis Obispo	201	32	40	29.82	30.04	−.02	62.5	+6.2	87	5	77	37	28	48	41	50	39	51	0.32	−1.4	3	2,661	n.	18	ne.	25	23	3	4	2.2	0.0	0.0
West Indies.																																
San Juan, P. R	82	9	54	29.85	29.94	.....	77.8	.....	88	10	83	69	15	72	16	....	....	....	8.08	+1.2	18	5,481	s.	31	e.	28	11	12	7	5.0	0.0	0.0
Panama Canal.																																
Balboa Heights	118	7	97	29.70	29.82	−.02	80.2	+1.1	90	28	86	70	4	74	16	75	74	87	8.81	+1.4	17	5,697	nw.	23	nw.	17	0	19	11	7.0	0.0	0.0
Colon	36	7	97	29.80	29.83	−.01	80.2	+1.1	88	27	84	72	26	75	13	....	....	....	15.31	−3.6	28	6,016	nw.	24	nw.	12	0	10	20	8.0	0.0	0.0
Alaska.																																
Juneau	80	11	54	29.64	29.73	.....	40.8	.....	64	7	45	27	20	37	19	38	36	84	11.71	.....	27	6,561	se.	42	se.	9	3	0	27	9.1	4.5	T.

TABLE II.—*Data furnished by the Canadian Meteorological Service, November, 1923.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125	29.92	30.06	+0.12	42.5	+6.0	46.9	38.2	63	25	9.73	+4.16	T.
Sydney, C. B. I.	48	30.04	30.09	+.14	42.8	+5.7	48.3	37.3	60	26	2.61	−2.83	0.0
Halifax, N. S.	88	29.95	30.06	+.05	42.0	+4.7	48.4	35.5	59	22	3.97	−1.69	0.0
Yarmouth, N. S.	65	29.94	30.01	−.01	41.7	+1.8	49.1	34.3	60	20	4.12	−0.44	0.4
Charlottetown, P. E. I.	38	30.00	30.04	+.08	41.3	+5.8	47.6	35.0	60	18	2.11	−1.86	T.
Chatham, N. B.	28	29.95	29.98	+.01	34.4	+3.4	42.2	26.5	58	13	4.45	+0.70	T.
Father Point, Que.	20	30.01	30.03	+.07	30.1	+1.2	36.6	23.7	46	14	4.26	+1.15	3.6
Quebec, Que.	296	29.72	30.06	+.04	33.2	+4.2	38.5	28.0	48	11	5.28	+1.52	6.1
Montreal, Que.	187	29.82	30.03	.00	35.6	+3.8	41.0	30.3	54	18	6.28	+2.54	15.0
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.77	30.04	+.02	35.8	+4.1	41.9	29.7	58	20	2.32	−0.22	4.1
Kingston, Ont.	285	29.74	30.06	+.02	39.4	+4.4	44.8	34.0	54	19	4.15	+0.91	1.1
Toronto, Ont.	379	29.64	30.06	+.02	39.0	+3.4	45.1	33.0	58	22	3.32	+0.18	2.2
Cochrane, Ont.	930												
White River, Ont.	1,244	28.61	29.96	−.02	28.8	+8.3	36.1	21.5	53	−2	0.63	−1.22	4.4
Port Stanley, Ont.	592	29.43	30.09	+.04	39.1	+2.3	45.3	33.0	55	24	3.63	+0.26	0.3
Southampton, Ont.	656	29.31			37.6	+2.6	44.1	31.1	58	23	2.21	−1.49	1.6
Parry Sound, Ont.	688	29.32	30.03	+.02	34.0	+1.9	40.9	27.2	53	11	2.45	−1.92	5.0
Port Arthur, Ont.	644	29.26	29.98	−.02	34.1	+10.1	40.5	27.8	52	12	0.67	−0.66	1.9
Winnipeg, Man.	760	29.10	29.95	−.09	34.3	+16.3	42.5	26.2	64	2	0.90	−0.18	2.8
Minnedosa, Man.	1,690	28.11	29.96	−.08	32.1	+14.8	42.3	22.0	60	5	0.43	−0.57	3.4
Le Pas, Man.	860				27.2		37.6	16.8	55	−5	0.47		3.4
Qu'Appelle, Sask.	2,115	27.64	29.92	−.08	32.6	+13.8	42.9	22.4	65	−2	1.72	+0.83	9.0
Medicine Hat, Alb.	2,144												
Moose Jaw, Sask.	1,759				34.3		45.4	23.3	66	10	2.35		8.0
Swift Current, Sask.	2,392	27.36	30.03	+.01	34.5	+11.3	47.8	21.3	66	4	0.78	+0.09	5.1
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Edmonton, Alb.	2,150												
Prince Albert, Sask.	1,450	28.36	29.97	−.06	29.5	+14.1	40.1	18.9	61	−5	0.23	−0.60	2.3
Battleford, Sask.	1,592	28.17	29.95	−.07	30.5	+14.2	42.8	18.1	64	0	T.	−0.58	T.
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.84	30.10	+.11	46.8	+3.6	50.7	42.9	57	36	2.90	−4.07	0.0
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151												

SEISMOLOGICAL REPORT FOR NOVEMBER, 1923.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, January 3, 1924.]

TABLE 1.—*Noninstrumental earthquake reports, November, 1923.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
	H. m.	**ARIZONA.**	° ′	° ′			*Sec.*			
Nov. 5	21 10	Yuma	32 40	114 35	4	1	12*ca*	None	Felt by many	J. H. Gordon.
7	24 00	....do	32 40	114 35	4	1	8–10	....do	....do	Do.
		ARKANSAS.								
Nov. 26	23 25	Marianna	34 45	90 40	2				Felt by several	C. M. Houch.
	23 27	Wynne	35 15	90 45	5	1	3*ca*	Faint	Felt by many	E. O. Allen.
	23 30	Jonesboro	35 55	90 35	4			Rumbling	Felt by several	M. Modesta.
	.. ..	....do	35 55	90 35	2				....do	Benedictine Sisters.
	.. ..	Marked Tree	35 30	90 20	4?	1	30*ca*	Rumbling	Felt by many	C. W. Walton.
		CALIFORNIA.								
Nov. 5	22 07	Calexico	32 41	115 30	7	Several.		None	Felt by many	R. Bradley.
	22 08	San Diego	32 40	117 10	2	2	1*ca*	....do	Felt by several	D. Blake.
7	23 50 *ca*	Chula Vista	32 30	117 00	3	1	20	....do	....do	N. D. Dittenhaver.
	23 56	San Diego	32 40	117 10	3	3	1½*ca*	....do	Felt by many	D. Blake.
	24 00	Calexico	32 41	115 30	7	3		....do	One fire caused	R. Bradley.
8	20 39	Santa Rosa	38 20	122 45	2–3	1	1	Faint	Felt by several	M. W. Allen.
9	5 *ca*	Los Angeles	34 03	118 15	Light.				Felt in near-by cities also	Press report.
28	3 50	Ojai	34 25	119 12	5	1	3	None	Felt by many	W. H. Duncan.
		ILLINOIS.								
Nov. 29	23 21	Cairo	37 00	89 10	3	1	15	Rumbling	Felt by many	W. E. Barron.
		KENTUCKY.								
Nov. 28	12 *or* 13	Calhoun	37 30	87 15	Light.					W. A. Taylor.
29	11 25	Wickliffe	37 00	89 05	4	1	15*ca*		Felt by several	J. A. Miller.
		TENNESSEE.								
Nov. 26	23 27	Memphis	35 10	90 00	4?	2	½*ca*		Felt by several	C. P. J. Mooney.
	.. ..	....do	35 10	90 00	4	2		None	Felt by many	J. D. Blagden.
	23 27 22	....do	35 10	90 00	4	1	45	Loud	Felt by several	J. P. Young.

78512—24——4

TABLE 2.—*Instrumental seismological reports, November, 1923.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols and description of stations, see REVIEW for January, 1923.]

ALASKA. *U. S. C. and G. S. Magnetic Observatory, Sitka.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923.		H. m. s.	Sec.	μ	μ	Km.		
Nov. 2	....	O	21 08 49	....	....	....	9,230	
		P_E	21 21 13					
		e_E	21 30 44					
		S_E	21 31 35					
		PS_E	21 32 40	18				
		$SR1_E$	21 37 31	13				
		L_E	21 46 35	40				
		eL_N	21 43 20	15				
		M_E	22 01 20	20	*400			
		M_N	22 00 05	20		*200		
		C_E	22 17 42					
		F_E	22 37 ..					
		F_N	22 30 ..					
3	....	S_E	8 58 22					
		S_N	8 57 48					
		L_E	9 16 57	13				
		L_N	9 09 32	19				
		M_E	9 18 25	12	*100			
		M_N	9 11 35	15		*200		
		F	9 33 ..					
4	....	e_E	0 27 08	17				
		L_E	0 42 34	36				
		eL_N	0 40 08	24				
		M_E	0 44 17	28	*500			
		M_N	0 41 42	20		*100		
		F_E	1 03 ..	19				
		F_N	1 12 ..					
16	....	P_E	4 18 05	5				Recorded on the magnetograph. Severe wind tremors.
		L_E	4 18 40					
		L_N	4 18 18	20				
		M_E	4 18 54	14	*2,100			
		M_N	4 18 55	14		*600		
		F_E	4 34 ..	8				
		F_N	4 30 ..	10				

ARIZONA. *U. S. C. and G. S. Magnetic Observatory, Tucson.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923.		H. m. s.	Sec.	μ	μ	Km.		
Nov. 1	....	e_E	9 10 45					
		L_E	9 13 09	8	*100			
		F_E	9 24 ..					
1	....	e_E	20 02 00	3				
		e_N	20 02 35					
		M_E	20 05 20	6	*200			
		M_N	20 06 53	6		*100		
		F_E	20 15 ..					
		F_N	20 09 ..					
2	....	O	21 08 48				10,040	N component not operating satisfactorily.
		P_E	21 21 52					
		PR^1_E	21 25 40	4				
		S_E	21 32 52					
		SR^2_E	21 44 12	36				
		iL_{E1}	21 52 36	40				
		L_{E2}	21 59 09	20				
		L_{E3}	22 01 45	19				
		M_E	22 04 00	19	*200			
		F_E	22 50 ..					
4	....	eP_E	0 22 04	5				
		e_E	0 29 45					
		eL_E	0 48 57	40				
		M_E	0 53 20	24	*300			
		F	1 18 ..	17				
5	....	P	22 09 58	3				Recorded on the magnetograph. e_E apparently another earthquake
		L_E	22 10 33					
		L_N	22 10 52	5				
		M_{E1}	22 11 28	3	*400			
		e_E	22 20 11					
		M_{E2}	22 22 09	20	*100			
		F_E	22 46 ..					
		F_N	22 22 ..					
7	....	P	23 57 58	2				Recorded on the magnetograph. Tremors superimposed on L_E.
		L_E	23 58 51	25				
		L_N	23 59 01	3				
		i_E	23 59 31					
		M_E	23 59 32	8	*5,400			
		M_N	23 59 07			*2,600		
		F	24 15 ..					
9	....	eL_E	3 27 11	11				No record on N.
		M_E	3 27 27	11	*200			
		F_E	3 48 ..	7				

* Trace amplitude.

CALIFORNIA. *Theosophical University, Point Loma.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923.			H. m. s.	Sec.	μ	μ	Km.	
Nov. 5	....	....	22 09 *ca*	....	350	400	....	Light shock.
8	....	....	0 01 *ca*	....	300	300	....	Do.
9	....	....	15 00 00	....	50	100	....	Tremors during preceding 24 hours.
15	....	....	....	....	50	50	....	
20	....	....	....	....	50	50	....	
21	....	....	....	....	50	50	....	
22	....	....	....	....	50	50	....	

COLORADO. *Regis College, Denver.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923.			H. m. s.	Sec.	μ	μ	Km.	
Nov. 2	....	P	21 53 ..	30	*1,500	*1,500	....	Perfect sinusoidal.
		F	22 07 ..					
4	....	L_E	24 51 ..	24	*2,000			Do.
		F_E	0 00 ..					
7	....	L	24 01 ..	8.5	*4,500	*6,000	....	No preliminaries.
		M	24 02 ..		*4,500	*6,000		
		F_N	24 19 ..					
		F_E	24 16 ..					
20	....	L	13 55 ..					Very small waves of short period vanishing and reappearing for 4 hours. *No quakes recorded in October.*
		F	17 50 ..					

DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923.			H. m. s.	Sec.	μ	μ	Km.	
Nov. 1	....	e	20 15 00					
		F	20 30 ..					
2	....	e	21 28 30					
		eL	22 05 ..	40				
		L	22 10 ..	28				
		L	22 20 ..	18				
		F	23 40 ..					
3	....	P?	8 42 17				2,200	
		S	8 45 55					
		eL	8 48 00	20				
		L	8 53 ..	15				
		F	9 45 *ca*					
3	....	P?	16 38 ..					
		eL	17 18 ..	28				
		L	17 28 ..	16				
		F	17 40 ..					
4	....	e	0 42 ..					
		eL	0 54 ..	28				
		L	1 04 ..	28				
		L	1 08 ..	24				
		L	1 12 ..	20				
		L	1 20 ..	16				
		F	1 50 *ca*					
5	....	e	21 53 ..					
		eL	22 22 ..	32				
		L	22 28 ..	28				
		L	22 35 ..	20				
		F	23 10 *ca*					
8	....	e	0 09 20					
		F	0 30 *ca*					
9	....	P	3 31 30					
		F	3 50 *ca*					
16	....	e	4 32 30					
		F	5 *ca* ..					
16	....	e	7 25 30					
		F	7 40 ..					
17	....	P	3 04 02				7,100	
		S?	3 12 35					
		eL	3 32 30					
		L	3 35 30	15				
		F	3 55 *ca*					

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, November, 1923*—Continued.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

1923.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Nov. 2	....	O.....	21 08 53	....	....	....	5,510	Most of E record lost through overlapping of traces.
		iP_E...	21 17 54	8	....	....	....	
		P_N....	21 18 04	....	....	....	....	
		S_N....	21 25 04	9	....	....	....	
		L_N1...	21 30 40	....	....	....	....	
		iL_N2..	21 31 25	....	....	....	....	
		M_N....	21 37 20	12	155	....	....	
		C_N....	21 51 ..	....	....	....	....	
		F_N....	23 05 ..	....	....	....	....	
3	....	i_E.....	16 38 41	15	....	....	....	
		e_N.....	16 38 35	....	....	....	....	
		e_N.....	16 46 00	....	....	....	....	
		L_E....	16 48 40	30	....	....	....	
		L_N....	16 49 37	26	....	....	....	
		M_E....	16 50 30	25	105	....	....	
		M_N....	16 50 50	25	....	60	....	
		F_E....	17 39 ..	....	....	....	....	
		F_N....	17 16 ..	....	....	....	....	
4	....	O.....	0 04 18	....	....	....	6,050	
		P_E....	0 13 52	3	....	....	....	
		eP_N...	0 13 58	....	....	....	....	
		iS.....	0 21 31	12	....	....	....	
		PS?$_E$..	0 22 04	11	....	....	....	
		SR2$_E$..	0 27 20	....	....	....	....	
		SR2$_N$.	0 27 00	15	....	....	....	
		L_E....	0 29 35	30	....	....	....	
		L_N....	0 30 20	25	....	....	....	
		M_E....	0 32 05	20	225	....	....	
		M_N....	0 31 28	25	....	300	....	
		F.....	1 31 ..	....	....	....	....	
4	....	e_E.....	20 29 ..	....	....	....	....	
		e_N.....	20 34 34	....	....	....	....	
		F.....	20 37 ..	....	....	....	....	
5	....	O.....	21 38 10	....	....	....	5,660	Do.
		P.....	21 47 21	20	....	....	....	
		iS_N....	21 54 38	30	....	....	....	
		SR1$_N$.	21 58 09	23	....	....	....	
		M_N....	21 59 08	21	....	95	....	
		F_N....	22 46 ..	....	....	....	....	
8	....	e_E.....	0 14 49	....	....	....	....	
		e_N.....	0 14 43	11	....	....	....	
		M_E....	0 17 08	10	15	....	....	
		M_N....	0 15 52	9	....	15	....	
		F_E....	0 24 ..	....	....	....	....	
		F_N....	0 21 ..	....	....	....	....	
9	....	e_E.....	3 41 45	....	....	....	....	
		e_E.....	3 43 56	10	....	....	....	
		e_N.....	3 41 10	15	....	....	....	
		M_E....	3 47 20	7	15	....	....	
		M_N....	3 43 10	9	....	10	....	
		F.....	3 53 ..	....	....	....	....	
10	....	e_E.....	4 23 16	....	....	....	....	Merely an irregularity in the microseisms.
		F_E....	4 28 ..	....	....	....	....	
12	....	e_N.....	12 05 00	....	....	....	....	Activity on E barely perceptible.
		M_N....	12 06 30	25	....	25	....	
		F_N....	12 10 ..	....	....	....	....	
16	....	e_E.....	4 31 10	....	....	....	....	Nothing on N.
		M_E....	4 32 50	10	20	....	....	
		F_E....	4 47 ..	....	....	....	....	
17	....	e_E.....	3 05 15	7	....	....	....	
		e_N.....	3 05 20	....	....	....	....	
		e_N.....	3 06 23	5	....	....	....	
		L_E....	3 07 15	14	....	....	....	
		L_N....	3 07 25	11	....	....	....	
		M_E....	3 12 28	9	25	....	....	
		M_N....	3 11 27	16	....	65	....	
		F.....	3 33 ..	....	....	....	....	
18	....	e_E.....	22 04 45	21	15	....	....	No definite maximum.
		F_E....	22 18 ..	....	....	....	....	
19	....	e_E.....	21 02 18	....	....	....	....	
		e_N.....	21 02 25	....	....	....	....	
		M_E....	21 05 30	6	5	....	....	
		F_E....	21 06 ..	....	....	....	....	
		F_N....	21 05 30	....	....	....	....	..
25	....	e_E.....	17 38 ..	18	....	....	....	Very slight.
		F_E....	17 48 ..	....	....	....	....	

Periods of pendulums: Before Nov. 15, 11.9 sec.; after Nov. 15, 12.0 sec.; Damping ratios: Near 30:1.
Sensitivities: Before Nov. 15; E., 0.168; N., 0.200; after Nov. 15; E., 0.174; N., 0.200. Multiplication: 150.

ILLINOIS. *U. S. Weather Bureau, Chicago.*

1923.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Nov. 1	....	P.....	20 08 46	....	....	....	....	
		S?.....	20 10 41	....	....	....	....	
		L.....	20 11 53	....	....	....	....	
		M.....	20 13 15	....	*5,000	....	....	
		F.....	21 *ca* ..	....	....	....	....	
2	....	P.....	21 26 00	....	....	....	9,700	
		S.....	21 36 45	....	....	....	....	
		L?....	21 56 00	60	....	....	....	
		L.....	22 01 30	40	....	....	....	
		L.....	22 10 ..	28	....	....	....	
		L.....	22 13 ..	18	....	....	....	
		L.....	22 20 ..	15	....	....	....	
3	....	F.....	0 50 *ca*	....	....	....	....	Continues.
3	....	e.....	3 35 ..	....	....	....	....	
		L.....	3 38 30	15	....	....	....	
		F.....	3 50 *ca*	....	....	....	....	
3	....	P.....	5 18 10	....	....	....	9,200	
		S?.....	5 28 30	....	....	....	....	
		eL....	5 45 ..	....	....	....	....	
		L.....	5 48 ..	20	....	....	....	
		L.....	5 52 ..	18	....	....	....	
		F.....	7 *ca* ..	....	....	....	....	
3	....	P.....	8 43 23	....	....	....	2,600	
		S.....	8 47 38	....	....	....	....	
		L?....	8 49 30	....	....	....	....	Jumbled.
		F.....	10 30 *ca*	....	....	....	....	
3	....	e.....	16 37 ..	....	....	....	....	
		eL....	17 05 ..	....	....	....	....	
		L.....	17 13 ..	22	....	....	....	
		L.....	17 18 ..	18	....	....	....	
		L.....	17 25 ..	16	....	....	....	
		F.....	18 10 ..	....	....	....	....	
4	....	P.....	0 23 56	....	....	....	8,500	
		S.....	0 33 42	....	....	....	....	
		eL....	0 52 ..	....	....	....	....	
		L.....	1 00 ..	30	....	....	....	
		L.....	1 05 ..	18	....	....	....	
		L.....	1 10 ..	16	....	....	....	
		F.....	3 *ca* ..	....	....	....	....	
4	....	eL....	20 58 ..	....	....	....	....	
		L.....	21 02 ..	22	....	....	....	
		L.....	21 06 ..	15	....	....	....	
		F.....	21 35 *ca*	....	....	....	....	
5	....	P.....	21 45 48	....	....	....	6,000	
		S.....	21 53 22	....	....	....	....	
		eL....	22 04 45	....	....	....	....	
		L.....	22 12 ..	38	....	....	....	
		L.....	22 21 ..	30	....	....	....	
		L.....	22 24 ..	22	....	....	....	
		L.....	22 30 ..	18	....	....	....	
6	....	F.....	1 00 ..		....	....	....	
6	....	P.....	17 27 26	....	....	....	9,000	
		S.....	17 37 35	....	....	....	....	
		eL....	18 02 ..	....	....	....	....	
		L.....	18 06 ..	15	....	....	....	
		F.....	18 30 *ca*	....	....	....	....	
8	....	P?....	0 04 05	....	....	....	....	
		L?....	0 08 40	....	....	....	....	
		F.....	1 *ca* ..	....	....	....	....	
9	....	P.....	3 25 42	....	....	....	3,200	
		S.....	3 30 42	....	....	....	....	
		F.....	4 20 *ca*	....	....	....	....	
11	....	e.....	5 59 00	....	....	....	....	
		F.....	6 10 *ca*	....	....	....	....	
11	....	e.....	14 22 ..	....	....	....	....	
		F.....	14 40 *ca*	....	....	....	....	
12	....	P?....	12 00 00	....	....	....	....	
		S?.....	12 08 35	....	....	....	....	
		eL....	12 20 00	22	....	....	....	
		L.....	12 27 ..	15	....	....	....	
		F.....	13 10 *ca*	....	....	....	....	
16	....	e.....	4 27 ..	....	....	....	....	Phases indistinct.
		F.....	5 40 *ca*	....	....	....	....	
16	....	e.....	7 24 ..	....	....	....	....	
		F.....	7 40 *ca*	....	....	....	....	
17	....	P.....	3 02 22	....	....	....	....	
		S?.....	3 11 10	....	....	....	....	
		L?....	3 21 ..	....	....	....	....	
		L.....	3 28 ..	16	....	....	....	
		F.....	5 50 *ca*	....	....	....	....	

TABLE 2.—*Instrumental seismological reports, November, 1923*—Continued.

ILLINOIS. *U. S. Weather Bureau, Chicago*—Continued.

			H. m. s.	Sec.	μ	μ	Km.	
1923. Nov. 18		P	21 45 44				11,300	
		S	21 57 36					
		eL	22 29 ..	22				
		L	22 39 ..	16				
		F	23 10 ca					
26		eL	13 40 ..					
		L	13 46 30	16				
		F	14 30 ca					

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

			H. m. s.	Sec.	μ	μ	Km.	
1923. Nov. 1		e_E	20 15 39	4	*100			
		i_N	20 15 29	4				
		e_N	20 17 03	10				
		M_N	20 17 20	10		*100		
		F_E	20 20 ..					
		F_N	20 22 ..					
2		e_E	22 00 16					e_E and e_N extremely weak.
		e_N	22 00 06					
		L_{E1}	22 05 57	28				
		L_{E2}	22 20 05	22				
		L_N	22 06 06					
		M_E	22 23 11	20	*500			
		M_{N1}	22 10 50	24		*200		
		M_{N2}	22 21 58	17		*200		
		F_E	22 45 ..					
		F_N	22 57 ..					
3		e_E	8 45 48					Nothing definite on E.
		P_N	8 42 56					
		e_E	9 04 05		*100			
		L_N	8 48 25	20				
		M_N	8 53 17	11		*100		
		F	9 14 ..					
4		e_E	0 42 07					
		e_N	0 58 07					
		L_E	1 05 09	28				
		M_E	1 08 12	26	*100			
		M_N	1 07 00	24		*200		
		F_E	1 22 ..					
		F_N	1 39 ..					
5		eP_N	22 16 56					
		eS_E	22 21 47					
		eL_E	22 28 42	24				
		eL_{N1}	22 27 52	30				
		eL_{N2}	22 33 27	17				
		M_E	22 30.38	24	*100			
		M_N	22 38 27	17		*100		
		C_N	22 42 ..					
		F_E	22 50 ..					
		F_N	23 17 ..					
8		e_N	0 13 14	4				No record on E. Tremors superimposed on the long waves.
		M_N	0 14 09	12		*200		
		F	0 18 ..					
16		e	4 36 24	4				Tremors superimposed on the M_N waves.
		M_E	4 37 18	4	*200			
		M_N	4 37 18	13		*200		
		F_E	4 41 ..					
		F_N	4 43 ..					

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques*

			H. m. s.	Sec.	μ	μ	Km.	
1923. Nov. 2		e_E	21 50 59	48				
		e_N	22 17 01					
		L_E	22 13 49	38				
		L_N	22 19 35					
		M_E	22 15 57	28	*500			
		M_N	22 21 30	20		*100		
		F_E	22 32 ..					
		F_N	22 27 ..					
3		P	8 39 22	2				Tremors superimposed on the long waves.
		S_N	8 40 34					
		L	8 40 58	22				
		M_E	8 42 20	14	*2,400			
		M_N	8 41 54	16		*9,800		
		C_E	8 43 52	12				
		C_N	8 43 00					
		F_E	9 18 ..					
		F_N	8 57 ..					
4		eL_E	1 14 33	24	*200			Heavy wind tremors.
		eL_N	1 15 48	20		*100		
		F	1 28 ..					

* Trace amplitude.

VERMONT. *U. S. Weather Bureau, Northfield.*

			H. m. s.	Sec.	μ	μ	Km.	
1923. Nov. 1		e	20 18 00					
		F	20 25 ca					
2		eL	22 07 ..					
		L	22 15 ..	24				
		L	22 18 ..	20				
		F	22 50 ca					
3		e	8 47 20					
		eL	8 55 30					
		F	9 20 ca					
4		eL	1 05 ..	24				
		L	1 10 ..	22				
		F	1 30 ca					
16		e	4 35 ..					
		F	4 50 ca					

CANAL ZONE. *Panama Canal, Balboa Heights.*

			H. m. s.	Sec.	μ	μ	Miles.	
1923. Nov. 2								Slight tremors from distant disturbance between 22*h*. and 23*h*.
5		P	14 23 16				300ca	Direction unknown.
		S_E	14 24 00					
		S_N	14 24 16					
		L_E	14 24 20					
		L_N	14 24 38					
		M_E	14 24 48		*1,400			
		M_N	14 24 40			*1,600		
		F_E	14 31 00					
		F_N	14 33 00					
12								Slight tremors from 6:24:12 to 6:29:00.
24		P_E	6 16 20				90ca	Direction unknown.
		P_N	6 16 18					
		F_E	6 17 36					
		F_N	6 17 14					
26								Very slight tremors between 7:56:20 and 7:57:20; apparently local.

CANADA. *Meteorological Service of Canada, Victoria.*

			H. m. s.	Sec.	μ	μ	Km.	
1923. Nov. 1		P	20 08 47	10				
		L	20 11 43	20				
E		M	20 14 10	18		10	1,700	
		F	20 21 56					
		P	20 08 49	10				
		L	20 11 43	20				
N		M	20 15 21	18	7		1,680	
		F	20 22 41					
2		P	21 21 10	10				
		S	21 31 20	20				
		L	21 49 20	25				
E		M	22 01 45	20		189	8,990	
		F	1 09 50					
		P	21 21 10	10				
		S	21 31 20	20				
		L	21 50 00	30				
N		M	21 51 41	25	93		8,990	
		F	0 33 50					
3		L	3 20 30	15				N-S too small to measure.
E		M	3 26 30	18		2		
		F	3 39 20					
3		P	5 14 00	8				
		?S	5 28 00	15				
		L	5 30 38	25				
E		M	5 44 12	18		6		
		F	6 15 45					
		L?	5 31 40	20				
N		M	5 37 19	14	3			
		F	5 49 50					
3		P	8 54 00	8				
		S	8 58 00	15				
		L?	9 05 40	20				
E		M	9 09 20	18		14	2,440	
		F	10 05 20					

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, November, 1923*—Continued.

CANADA. *Meteorological Service of Canada, Victoria*—Continued.

1923.			H. m. s.	Sec.	μ	μ	Km.	
Nov. 3		P	8 54 00	10				
		?S	8 56 40	15				
		L	9 02 48	20				
N		M	9 06 40	14	24		1,530	
		F	10 19 20					
3		P	16 31 15	10				
		S	16 41 09	12				
		L	16 57 57	20				
E		M	17 04 17	20		14	8,670	
		F	18 07 07					
		S	16 41 15					
		L	16 58 37	20				
N		M	17 14 07	16	9			
		F	.. ? ..					
4		P	0 17 27	10				
		S	0 27 55	18				
		L	0 44 52	28				
E		M	0 47 55	28		272	9,350	
		F	2 39 57					
		S?	0 28 15	20				
		L?	0 41 12	30				
N		M	0 46 57	30	125			
		F	2 32 27					
4		P	20 28 16	8				N-S too small to measure.
		L	20 45 14	20				
E		M	20 45 51	20		13		
		F	21 06 56					
4		P	22 57 21	6				N-S too small to measure.
		L	23 02 56	20				
E		M	23 05 41	18		6		
		F?	23 09 56					
5		P	21 40 13	5				
		S	21 49 55	18				
		L	22 02 45	35				
E		M	22 08 43	30	40		8,440	
		F	0 12 55					
		P	21 40 00	5				
		S	21 49 55	12				
		L	22 06 31	25				
N		M	22 07 35	25		36	8,690	
		F	0 23 25					
6		L	18 04 20	20				
E		M	18 09 55	15		4		
		F	18 25 20					
		L	18 04 30	25				
N		M	18 06 40	20	7			
		F	18 22 00					
8		P	0 04 10	10				
		L	0 05 55	20				
E		M	0 07 35	12		33		
		F	0 31 30					
		P	0 04 00	10				
		L	0 06 00	15				
N		M	0 07 57	12	22			
		F	0 56 30					
9		P	3 32 29	8				
		L	3 37 57	20				
E		M	3 40 54	18		14		
		F	4 23 59					
		P	3 32 29	8				
		L	3 37 52	20				
N		M	3 41 08	15	16			
		F	4 12 00					
10		P	21 46 38	8				
		L	22 05 53	20				
E		M	22 10 18	20		4		
		F	22 33 38					
N		M	22 06 08	20	1			
11		L	5 55 33	4				
E		M	5 57 08	10		2		
		F	6 02 48					
		L	5 55 28	20				
N		M	5 56 48	10	2			
		F	6 01 48					
11		L	14 24 23	10				
E		M	14 26 30	10		2		
		F	14 35 16					
		L	14 24 38	8				
N		M	14 28 08	10	1			
		F	14 37 28					

CANADA. *Meteorological Service of Canada, Victoria*—Continued.

1923.			H. m. s.	Sec.	μ	μ	Km.	
Nov. 12		L	12 01 53	10				
E		M	12 05 08	20		6		
		F	12 51 43					
		L	12 02 04	10				
N		M	12 04 08	18	5			
		F	12 39 58					
16		P	4 17 15	5				
		L	4 18 47	12				
E		M	4 19 23	10		67	850	Calif.
		F	4 54 55					
		P	4 17 15	5				
		L	4 18 50	12	100			
N		M	4 19 25	10				
		F	4 56 15					
16		L	1 10 49	5				
E		M	1 11 36	12		7		
		F	1 12 54					
		L	1 10 51	5				
N		M	1 11 24	10	5			
		F	1 15 12					
17		P	3 00 08	4				
		S	3 05 35	8				
		L	3 10 08	20				
E		M	3 10 14	20		17	3,660	
		F	4 19 13					
		P	3 00 08	4				
		S	3 05 34	8				
		L	3 10 44	20				
N		M	3 10 44	20	20		3,630	
		F	4 19 53					
18		P	21 42 05	4				
		S	21 52 49	10				
		L	22 10 19	25				
E		M	22 24 27	20		9	9,680	
		F	23 13 34					
		P	21 42 04	4				
		S	21 52 59	10				
		L	22 05 29	20				
N		M	22 26 19	16	4		9,930	
		F	23 14 49					
19		L	9 20 58	12				
E		M	9 25 09	12		4		
		F	9 30 23					
		L	9 20 28	15				
N		M	9 26 58	12	4			
		F	9 31 48					
26		P	13 03 47	10				
		L	13 42 34	30				
E		M	13 59 02	20		6		
		F	14 23 02					
		P	13 03 42	10				
		L	13 39 32	30				
N		M	13 57 42	20	6			
		F	14 20 02					

The seismograph of Fordham University, New York City, was laid up for repairs from October 30 to November 19. On November 19 the machine was reassembled. Frequent shocks, probably of local origin, were recorded during that day; on November 20 the shocks were less numerous, but the record showed microseisms having trace amplitudes of 1 to 2 millimeters, and period of 10 seconds, lasting throughout the 24 hours. No earthquakes were recorded.

Reports for November, 1923, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.
DISTRICT OF COLUMBIA. *Georgetown University*, Washington.
MASSACHUSETTS. *Harvard University*, Cambridge.
MISSOURI. *St. Louis University*, St. Louis.
NEW YORK. *Cornell University*, Ithaca.
CANADA. *Meteorological Service of Canada*, Toronto; *Dominion Observatory*, Ottawa.

TABLE 3.—*Late reports (instrumental).*

CANADA. *Dominion observatory, Ottawa.*

1923.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 1		O	2 58 59				9,760	
		eP	3 11 49					
		iS	3 22 36					
		eL	3 37 ..	(60)				
		M	3 53 30	20	381			
		L	4 03 ..	17	171			
		L	4 30 ..	16	71			
		L	4 54 ..	14	37			
		L	5 16 ..	14	16			
		L	5 48 ..	14	9			
		L	6 05 ..	13				
		L	6 40 ..	13				
		L	7 05 ..					
		eL	8 20 ..					
		L	8 25 ..	28	15			
		L	8 34 ..	19	9			
		L	8 50 ..	13				
		F	9 50 ..					
		Saskatoon record.						
		O	2 58 35				8,520	
		P	3 10 25					
		S	3 20 09					Good record on both horizontal components.
		eL	3 31.5*ca*					
		Halifax record.						
		O	2 58 55				10,050	
		P	3 12 00					
		PR$_1$	3 15 50					
		S	3 23 00					
		SR$_1$?	3 29 18					
		eL	3 42 30					
2		O	2 47 11				9,560	
		P	2 59 52					
		PR$_1$	3 03 49					
		S	3 10 30					
		i	3 12 17					
		SR$_1$	3 17 30					
		eL	3 32 ..					
		M	3 48 ..	19	247			
		F	7 00 ..					
2		O	(9 24 06)				9,900	
		P	(9 37 0)					
		PR$_1$	(9 40 42)					
		S	(9 47 54)					Time marks failed on all seismographs.
		SR$_1$	(9 54 12)					
		SR$_2$	(9 58 18)					
		eL	(10 04)..					
		M	(10 22)..					
		F	(12 30)..					
2		e	13 51 ..					Milne-Shaw only.
		eL	13 57 ..					
		L	14 02 to					
		L	14 07 ..					
		F	14 30 *ca*					
2		e	15 06 42					
		L	15 10 ..					
		F	15 21 *ca*					
2		O	(22 38 36)				6,340	
		P	(22 48 30)					
		S	(22 56 24)					
		SR$_1$?	(23 01 42)					Time marks uncertain.
		eL	(23 05)..					
		M	(23 09)..					Irreg.
		F	1 10 *ca*					
9		O	4 18 18					
		P	4 25 52				4,220	
		S	4 31 52					Very faintly defined.
		eL	4 36 30					
		F	5 05 ..					
9		eL	18 03 42					Faint traces on N-S only.
		L	18 08 ..					
		F	18 15 ..					
9		O	22 13 17					
		P	22 22 45				(5,960)	
		S	22 30 19					
		eL	22 38 08					
		M	23 00 ..	34				
		L	23 04 ..	(26)				
		L	23 18 ..	(16)				
		F	1 20 ..					
10		e?	9 51 30					
		eL	9 54 ..					
		L	9 59 ..					
		F	10 27 *ca*					
10		e?	12 52 30					
		eL	12 55 ..					
		F	13 05 ..					
11		e	9 15 52					
		i(S?)	9 20 08					
		eL	9 24 ..					
		L	9 27 ..					
		F	9 55 *ca*					
12		e?	(6 14)..					Time marks uncertain.
		i	(6 20 30)					
		e	(6 23)..					Slight traces. Only on M-S.
		L	6 55 ..	15				
		F	7 25 ..					

CANADA. *Dominion observatory, Ottawa*—Continued.

1923.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 14		e						Lost in changing sheets.
		eL	13 48 to	15				
		F	14 10 ..					
16		e?	16 55 17					
		i	16 55 59					
		e	17 02 40					
		e	17 07 27					Sinusoidal L waves.
		e	17 13 40					
		eL	17 36 42					
		L	17 42 ..	19	8			M-S record only.
		L	18 01 ..	15				
		L	18 44 ..	18				
		F	19 25 ..					
17		e?	4 03 10					
		e	4 11 24					
		eL?	4 24 ..					
		L	4 32 ..					Faint traces only. M-S.
		F	4 50 ..					
17		i	7 32 45					
		eL	7 45 ..					
		M	7 52 ..	28	12			Sinusoidal L waves.
		L	8 01 ..	15	8			
		L	8 20 ..	12				
		F	9 hr *ca*					
18		L	4 38 to					Faint sinusoidal L waves on Milne-Shaw only.
		F	4 40 ..					
19		e	8 39 to					Irregular faint traces on Milne-Shaw only.
		F	8 52 ..					
19		e	19 47 to					Faint traces only.
		F	19 58 ..					
20		e	9 33 to					Faint irregular traces only.
		F	9 49 ..					
20		eL	(16 00)..					Faint sinusoidal L waves. M-S only. Time uncertain.
		F	(16 02)..					
21		ez	20 24 15					
		eL	20 49 to					
		L	20 54 ..	16	1			No. 17 only.
		L	21 00 to					
		L	21 06 ..	14				
		F	21 15 ..					Faint sinusoidal L waves.
22		e	(12 47)..					
		i	12 50 30					
		F	13 10 ..					
22		eL	15 50 to	23				
		L	16 25 ..	17				Small amplitude—less than 1 μ.
		F	16 35 ..					
22		P?	21 04 20					
		e	21 11 24					
		i	21 15 28					
		eL?	21 26 ..					
		L	21 29 ..	50	70			
		L	21 45 ..	17	21			
		L	22 04 ..	14	3			
		L	23 05 ..	18				Very small trace at 23: 30:
		F	0 00 *ca*					
23		eL	4 04 to	9				Faint regular traces of small amplitude and short period.
		F	4 30 ..					
23		i	17 44 08					
		e	17 47 48					
		eL?	17 52 42					
		M	17 57 30	11	6			
		L	18 10 ..	10				
		F	18 35 ..					
23		e	21 31 30					
		eL	21 35 36					No. 17 only.
		F	21 52 ..					
24		eL	16 11 ..					Faint sinusoidal trace.
		F	16 13 ..					
26		e?	(2 43)..					Time marks uncertain throughout.
		i	(2 47 42)					
		eL	(2 54 18)					
		L	3 10 ..	13				No definite phase markings.
		F	3 50 ..					
26		e	8 48 12					
		eL?	9 05 ..					
		L	9 11 ..					
		M	9 19 ..	20				No definite phases shown.
		L	9 26 ..	14				
		L	9 43 ..	14				
		L	10 03 ..	14				
		F	10 40 *ca*					
27		e	(7 36 48)					On M-S only. Faint traces.
		eL?	(7 41 36)					Sinusoidal L waves.
		L	8 05 ..	16				
		L	8 25 ..	16				
		F	9 hr. *ca*					

TABLE 3.—*Late reports (instrumental)*—Continued.

CANADA. *Dominion observatory, Ottawa*—Continued.

1923.			*H. m. s.*	*Sec.*	μ	μ	*Km*	
Sept. 28		e	21 15 10					Except for about 5 minutes at the maximum, the record is a faint trace of irreg. wavelets.
		eL	21 18 50					
		M	21 23 ..					
		F	22 05 ..					Irreg.
29		eL	7 46 to					Very faint sinusoidal trace of No. 17 only.
		F	7 58 ..					
30		O	1 20 56				3,040	
		P	1 26 56					
		S	1 31 42					
		eL?	1 34 *ca*					
		M_{17}	1 40 ..	12	300			
		L	1 50 ..	10				
		L	2 17 ..	10				
		L	2 44 ..	10				
		L	3 17 ..	11				
		L	4 45 ..	18				
		L	5 12 ..	10				
		L	5 30 *ca*					
Oct. 1		e?	8 55 ..					
		eL	9 04 ..	30				
		L	9 13 ..	19				
		L	9 19 ..	16				
		F	9 48 ..					
1		O	22 40 21				10,040	
		P	22 53 25					
		S	23 04 25					Well marked phases.
		eL	23 24 ..	31	5			
		L	23 33 ..	16				Very small amplitudes.
		L	23 43 ..	15				
		F	0 10 ..					
3		eL	16 35 ..					
		L	16 42 ..	18				
		F	16 55 ..					
4		i	17 50 40					Irregular traces preceded by a sharp impulse.
		L	18 03 ..					
		F	18 25 ..					
7		O	(3 26 06)				(12,140)	
		eP	3 51 09					
		S	(4 03 35)					
		e	4 08 30					
		e_1	4 13 48					Sinusoidal L waves.
		eL_1	4 31 ..					
		M	4 43 ..	19	70			
		L	4 50 ..	19	30			
		L	5 13 ..	16				
		L	5 35 ..	16				
		L	6 02 ..	15				
		L	6 35 ..	13				
		F	7 10 ..					
8		O	3 52 28				1,570	
		eP	3 55 49					
		eS	3 58 33					
		eL	3 59 30					
		M	4 03 ..	21	7			Very faint L waves after 4–06.
		L	4 06 ..	13				
		F	4 50 ..					
10		O	7 11 08				4,460	
		iP	7 18 59					
		iPR_1	7 20 30					
		iS	7 25 12					
		SR_1	(7 28 24)					
		SR_2	(7 29 12)					
		eL_{II}	7 31 30					
		M_{17}	7 33 ..	17	45			
		L_{17}	7 42 ..	9	10			
		L	7 55 ..					Irreg. small.
		F	9 hr. *ca*					
10		e	23 06 to					Faint traces of L waves on M–S only.
		F	23 30 ..					
11		e	12 41 30					
		eL?	12 45 ..	16				
		L	12 52 ..	13				
		L	13 00 ..	13	1			Small sinusoidal L waves.
		F	13 25 ..					
13		e	4 41 18					
		eL	4 46 ..					
		M	4 48 ..	12	13			
		L	5 01 ..	7				
		F	5 30 ..					
15		e	(8 25) ..					
		eL?	(8 48) ..					Horizontal slit on M–S was partially obscured by a bit of lint at light spot. No definite record.
		L	9 15 ..	19				
		L	9 33 ..	16				
		L	10 00 ..	16				
		F	10 15 *ca*					
15		eL	20 45 ..					Faint sinusoidal L waves.
		L	20 46 ..	12	1			
		F	20 55 ..					
Oct. 17		e	6 54 to					Faint irregular traces, M–S.
		F	7 08 ..					
18		eL	22 13 ..					
		L	22 18 ..	20				Sinusoidal L waves.
		F	22 25 ..					
20		eL	4 06 ..	30				
		L	4 22 ..	16				Irregular to sinusoidal L waves.
		L	4 30 ..	14				
		F	4 40 ..					
21		e	19 16 38					Irregular small wavelets.
		F	19 35 ..					
22		e	16 22 48					Faint trace, M–S only. Lost in micros.
		F	16 33 ..					
26		e	19 39 to					Faint irregular traces on M–S only.
		F	19 49 ..					

CANADA. *Meteorological Service of Canada, Toronto.*

1923			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 1		i	?8 55 30					Preceded by micros.
		i	8 58 53					
		e	9 03 36					
W		L	9 11 42					
		L	9 12 38	25				
			Sinusoidal to 9 15 52			15		
		L	9 18 43					
		F	?10 00 00					
		i?	9 00 36					Preceded by micros.
		eL	9 12 20					
N			Very slow waves to 9 17 00					This component very little affected.
		eL	9 21 30					
		F	9 54 00					
1		e	22 53 21					
		e	23 04 26					
		i	23 05 40					
		L	23 18 23					
W		eL	23 24 00	30				
		L	23 30 58	23		6		
		L	23 39 43 to 23 42 38	19				
		F	Micros.					Marked micros going on.
N		i	23 05 39					N-S component very little affected.
		L	23 30 55					
		F	Micros.					
5 W		eL	1 35 30					N-S component M very slightly affected.
		F	1 55 00					
7		P	3 51 00					
		PR1	3 52 11					Lines crowded.
		i	3 53 10					
		e	4 00 15					
		S	4 02 57					
W		iS	4 03 14					S waves very irregular.
		i	4 14 00	17				
		L	4 27 38	28				
		L	4 29 41	23			(11,410) (11,830)	
			Sinusoidal to 4 49 34	} 20 to 23	}	108		
		M	3 38 47					
			4 39 02					
		L	4 49 52					
		P	3 50 55					
		PR1	3 52 15					
		i	4 01 15					
		S	4 02 52	12				S waves difficult to interpret.
			4 03 16					
		i	4 04 00	15				
N			Sinusoidal to 4 05 00				(11,410)	
		L?	4 24 00	22			(11,830)	
		L	4 30 45	45				
		L	4 37 45					
			Sinusoidal to 5 04 00					
		M	4 46 17	20	56			
		F	7 14 00					
7		e	7 27 02					May not be seismic.
		e	7 40 03					

TABLE 3.—*Late reports (instrumental)*—Continued.

CANADA. *Meteorological Service of Canada, Toronto*—Continued.

			H. m. s.	Sec.	μ	μ	Km.	
1923. Oct. 8		P	3 49 46					Crowding of line on E-W component.
		PR1	3 50 58					
		e	3 55 11					
N		L	3 58 19 to 4 03 45					
		eL	4 04 00 to 4 09 43	15	6			
		F	4 23 00					
		e	3 55 15					
		e	3 57 50					
		L	3 58 08					Lines crowded.
		L	4 00 00	30		16		
W			Sinusoidal to 4 07 00	23				
		L	4 07 23	15				
		F						
10		iP	7 19 17	7				
		PR1	7 21 05					Phases well defined.
		S	7 25 46					
		i	7 25 53					Six well defined M.
		iSR1	7 29 07					
		i	7 29 21	12				
		i	7 30 39				4,760	
W		L	7 32 37	23				
			Sinusoidal to					
		L	7 34 ..					
			7 42 ..	19				
		M	7 34 17	17		58		
		L	7 42 14					Irregular.
		F	9 28 00					
		iP	7 19 15	8 to 10				
		1PR1	7 21 08					
		iS	7 25 49	?12				Phases well defined.
		L	7 32 26	19			4850	
		L	7 33 38 to 7 45 50					
		M	7 38 55	12 to 13.	46			
		L	7 46 00					Waves became smaller.
		F	9 18 00					
10		eL_E	23 01 38					
		e_E	23 27 45					
		e_N	23 02 55					Undulatory.
11		e	12 57 08					
		L	13 03 25					Nothing definite.
		L	13 08 30					
		L	13 31 34					
		F	?13 41					
		L	12 59 06					
		L	13 08 38					Very small amplitude.
		F	13 24 00					
13		i?	4 32 45					
		e	4 43 29					P and S masked by micros.
		L	4 46 15					
W		L	4 46 39	23				
			Uniform waves to 4 48 38	13 to 8				
		L	4 49 00	and 10		8		
		M	4 48 00					
		F	5 31 00					
N		e?	4 40 55					
		e	4 45 30	9				
		L	4 46 32					
		iL	4 46 53					Micros masked early phases.
			Uniform to 4 48 38	11				
		M	4 47 38	14	12			
		F	?5 30 00					

CANADA. *Meteorological Service of Canada, Toronto*—Continued.

			H. m. s.	Sec.	μ	μ	Km.	
1923. Oct. 15		iP?	8 01 41					
		e?	8 07 09					
		e	8 13 45					No defined phases.
		L	8 28 00					
		L	8 44 52					
		eL	9 12 26					
W			Undulatory to 10 03 00	19 to		6		
		F	10 22 ..	23				
		iP	8 01 43					Nothing defined, micros going on.
		e	8 07 15					
		eL	8 24 53					
N			Undulatory to	15 to				
			8 38 38	18				
		L	8 42 15	15	4			
		F	16 16 ..					
15		L	?20 45 00					
		L	20 53 41					Small amplitude.
W		F	21 02 ..					N-S component only a very slight record.
17		L	6 01 06	15				
W			Small sinusoidal to— 6 04 37					
		F	Micros..					
18		L	22 13 36					
N		F	Micros..					Micros on E-W component.
19		L	23 02 08					
N			Small sinusoidal waves to— 23 06 38					
		F	Micros..					E-W component, micros.
20		L	18 32 34					
		L	18 43 40					
N		F	Micros..					E-W component, masked by micros.
21		i	19 16 48	5				
			Undulatory to 19 18 15	11				
W			19 18 49					
		L	19 20 53					
		F	19 27 00					
		i	19 16 49					
		i	19 17 07	5				
N		L?	19 20 40					Very small amplitude.
		F	?19 25 00					
26		e	19 40 15					Irregular and very small amplitude.
N		F	19 50 00					E-W component, micros.
26								Power off from 23h. 07m. 15s. to 12h. 51m. on the 27th.

Chart I. Tracks of Centers of Anticyclones, November, 1923. (Inset) Departure of Monthly Mean Pressure from Normal.
(Plotted by Wilfred P. Day.)

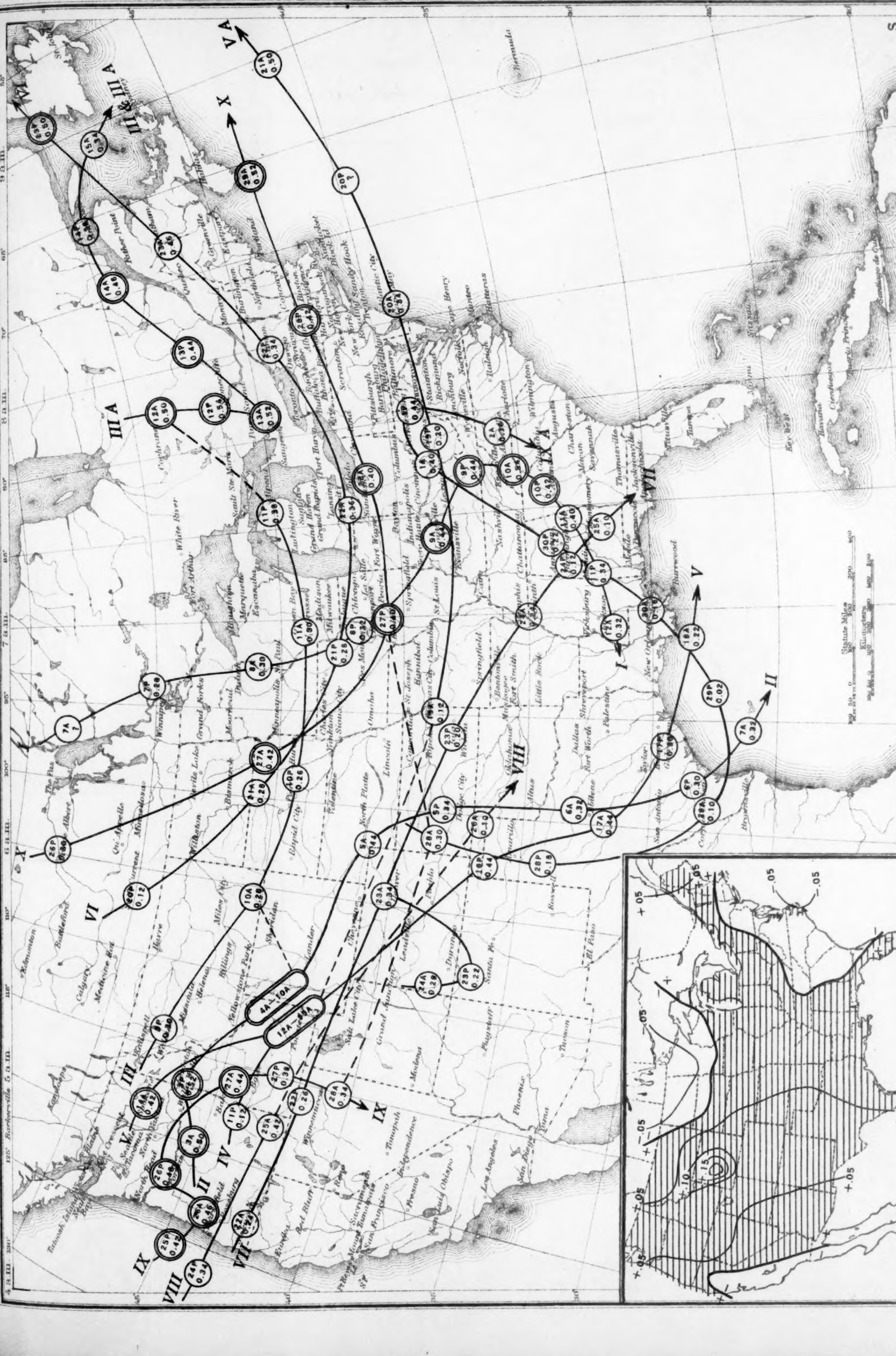


Chart II. Tracks of Centers of Cyclones, November, 1923. (Inset) Change in Mean Pressure from Preceding Month.

(Plotted by Wilfred P. Day.)

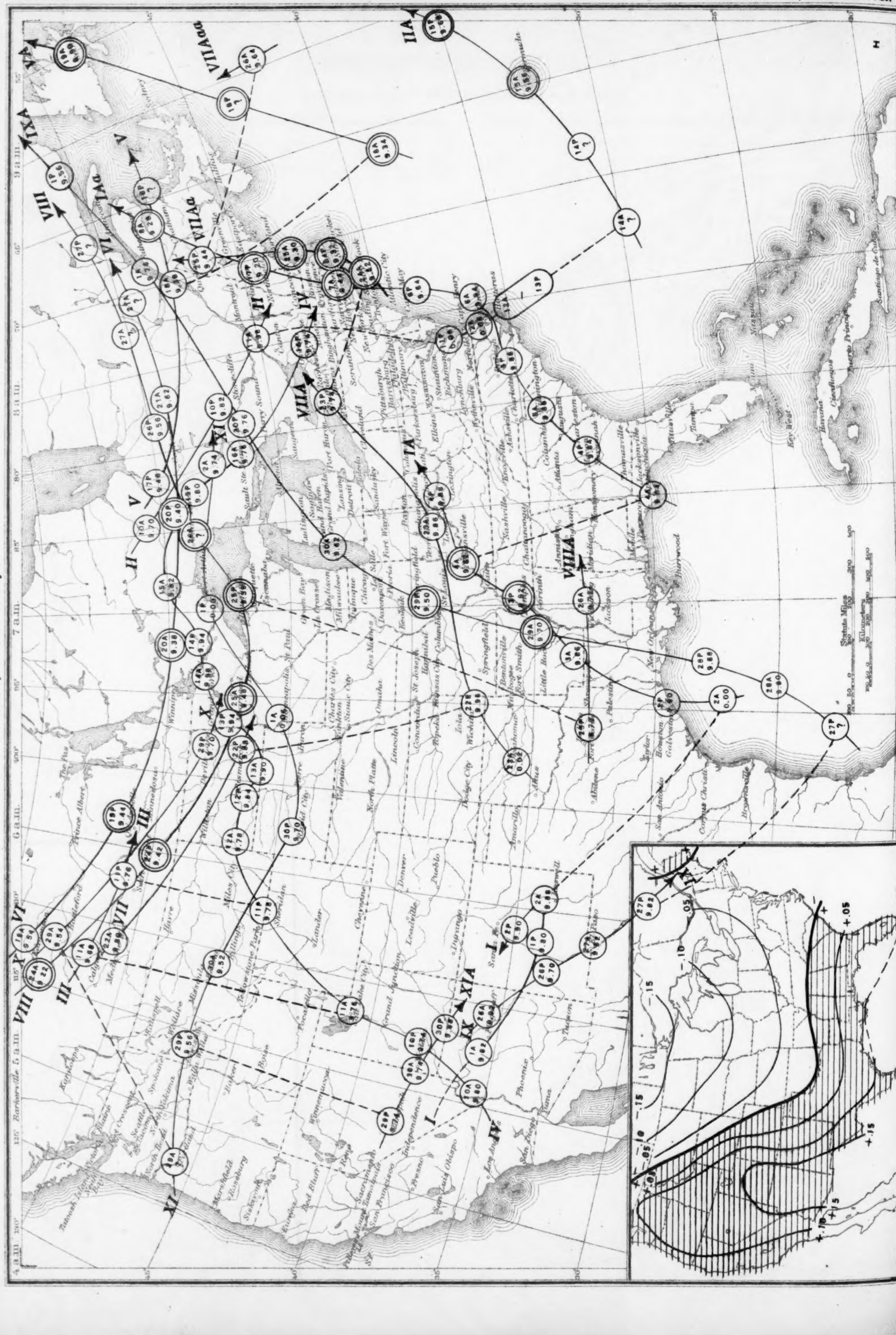


Chart III. Departure (°F.) of the Mean Temperature from the Normal, November, 1923.

Chart III. Departure (°F.) of the Mean Temperature from the Normal, November, 1923.

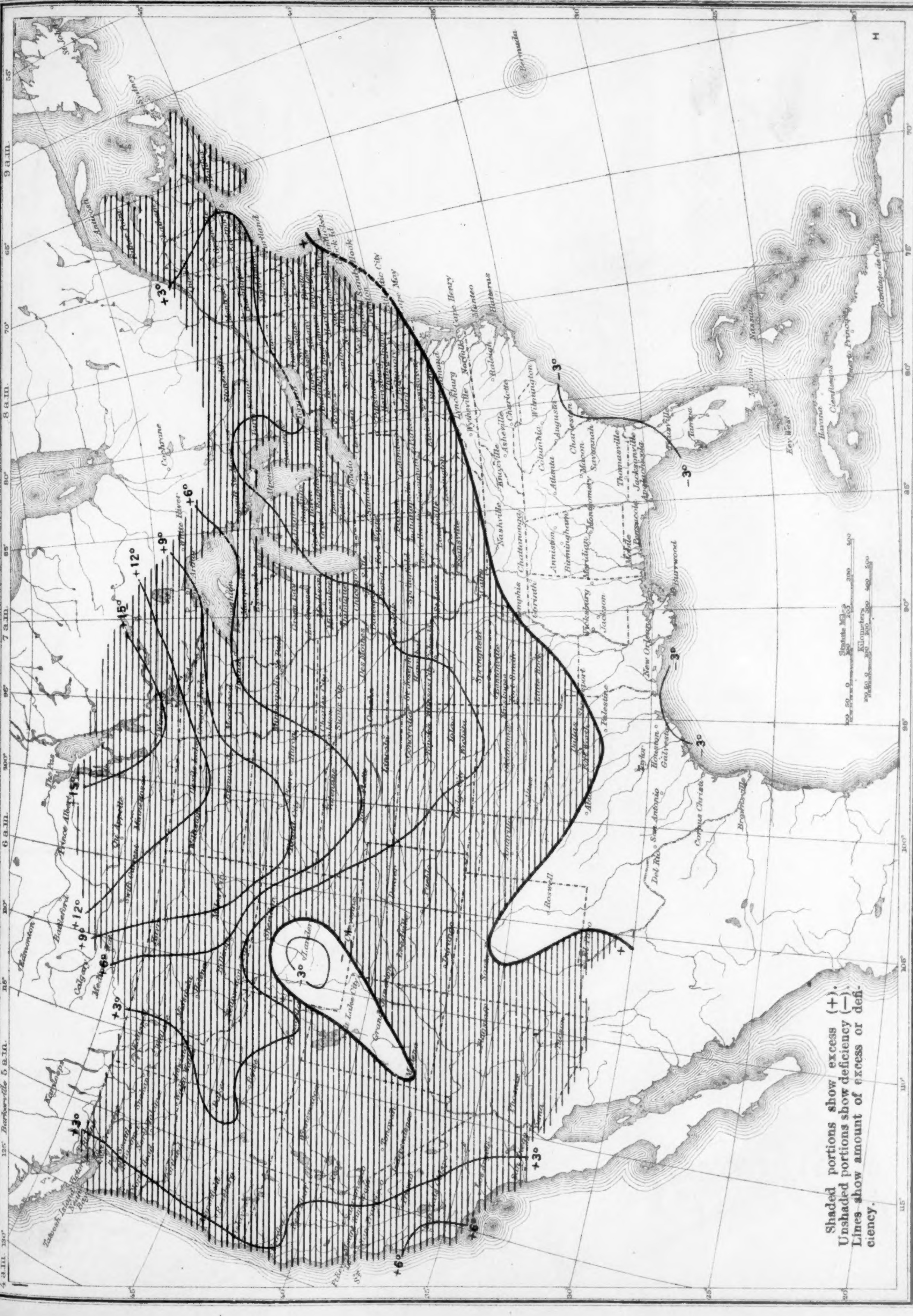
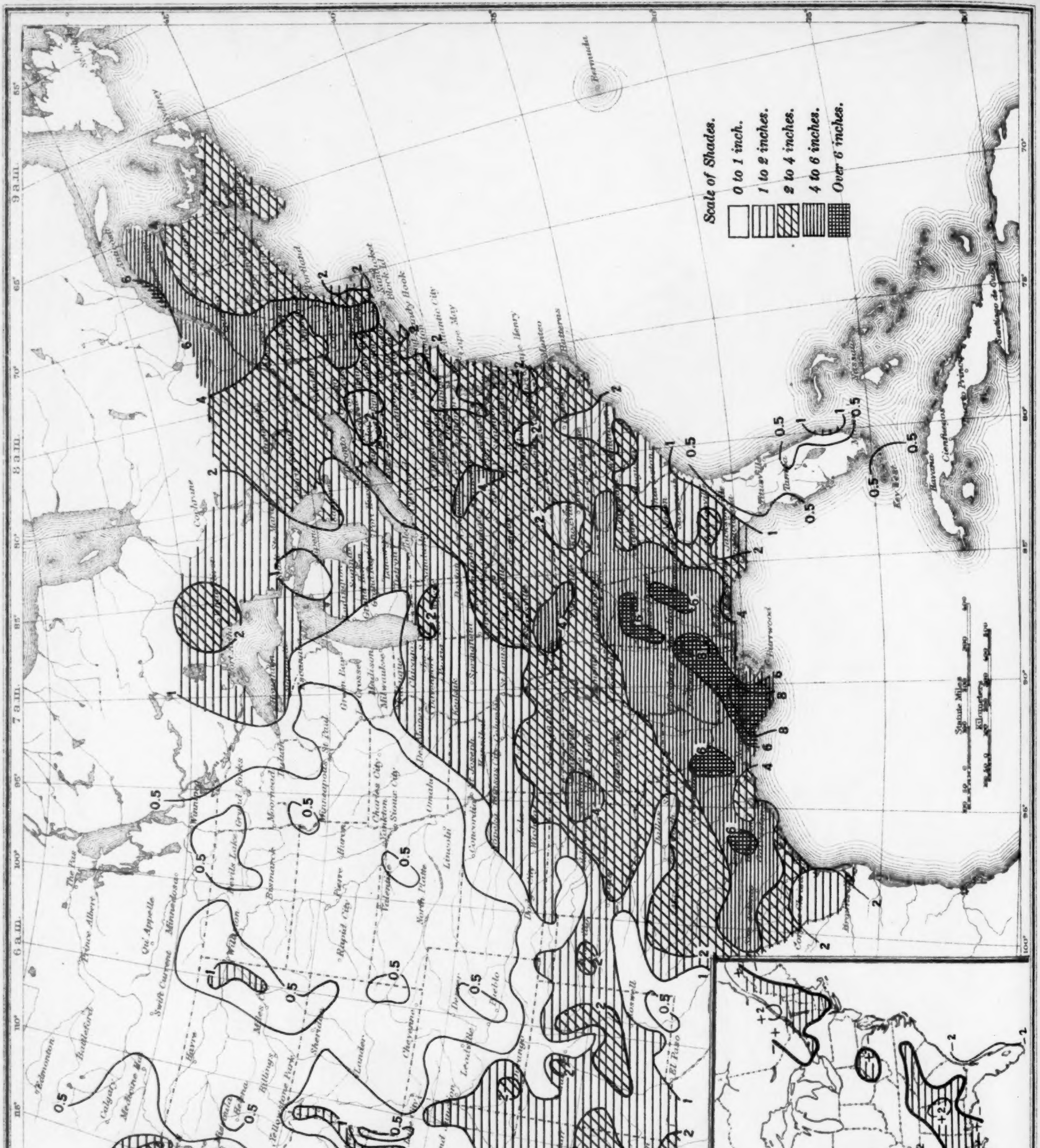


Chart IV. Total Precipitation, Inches, November, 1923. (Inset) Departure of Precipitation from Normal.



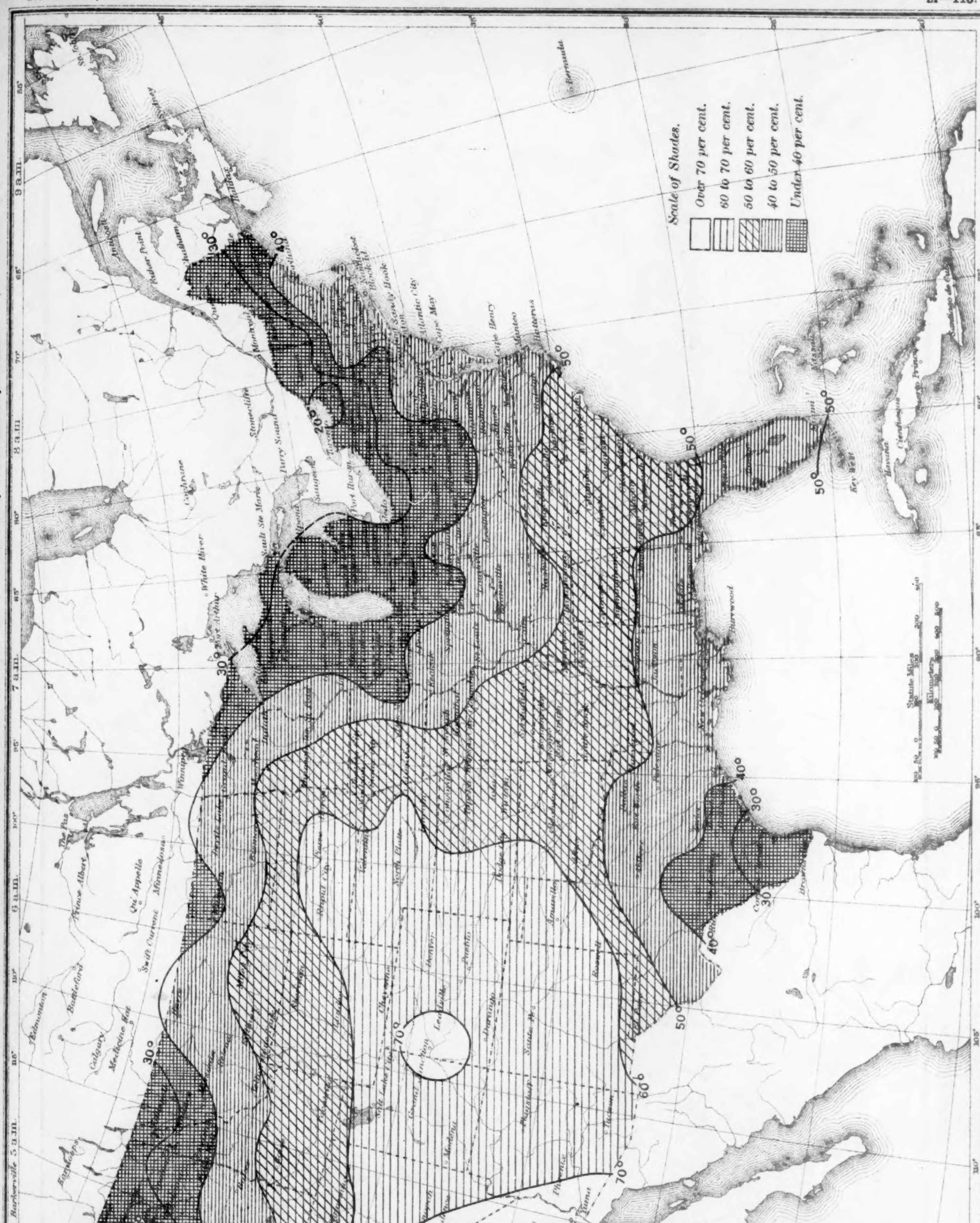


Chart V. Percentage of Clear Sky between Sunrise and Sunset, November, 1923.

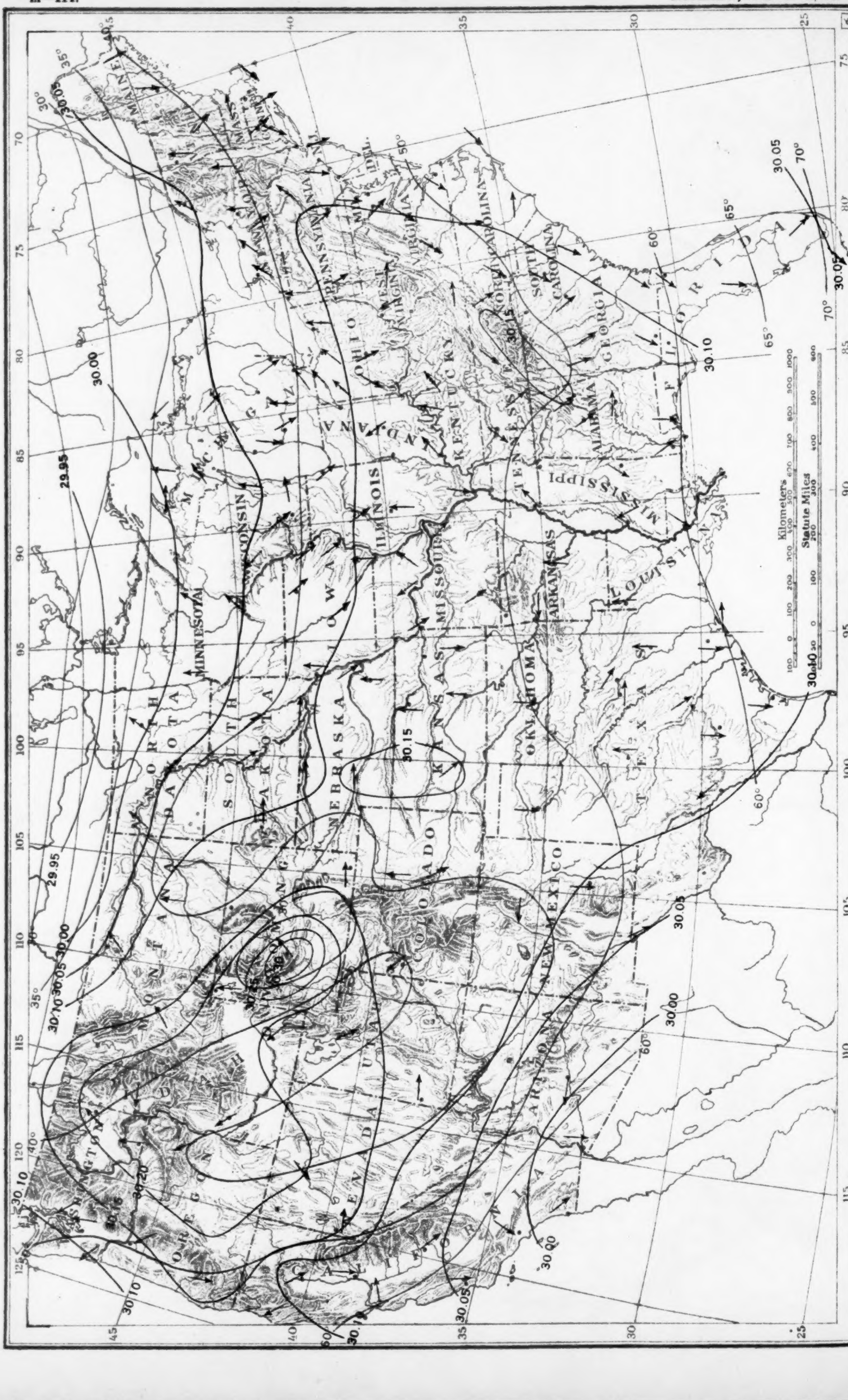


Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, November, 1923.

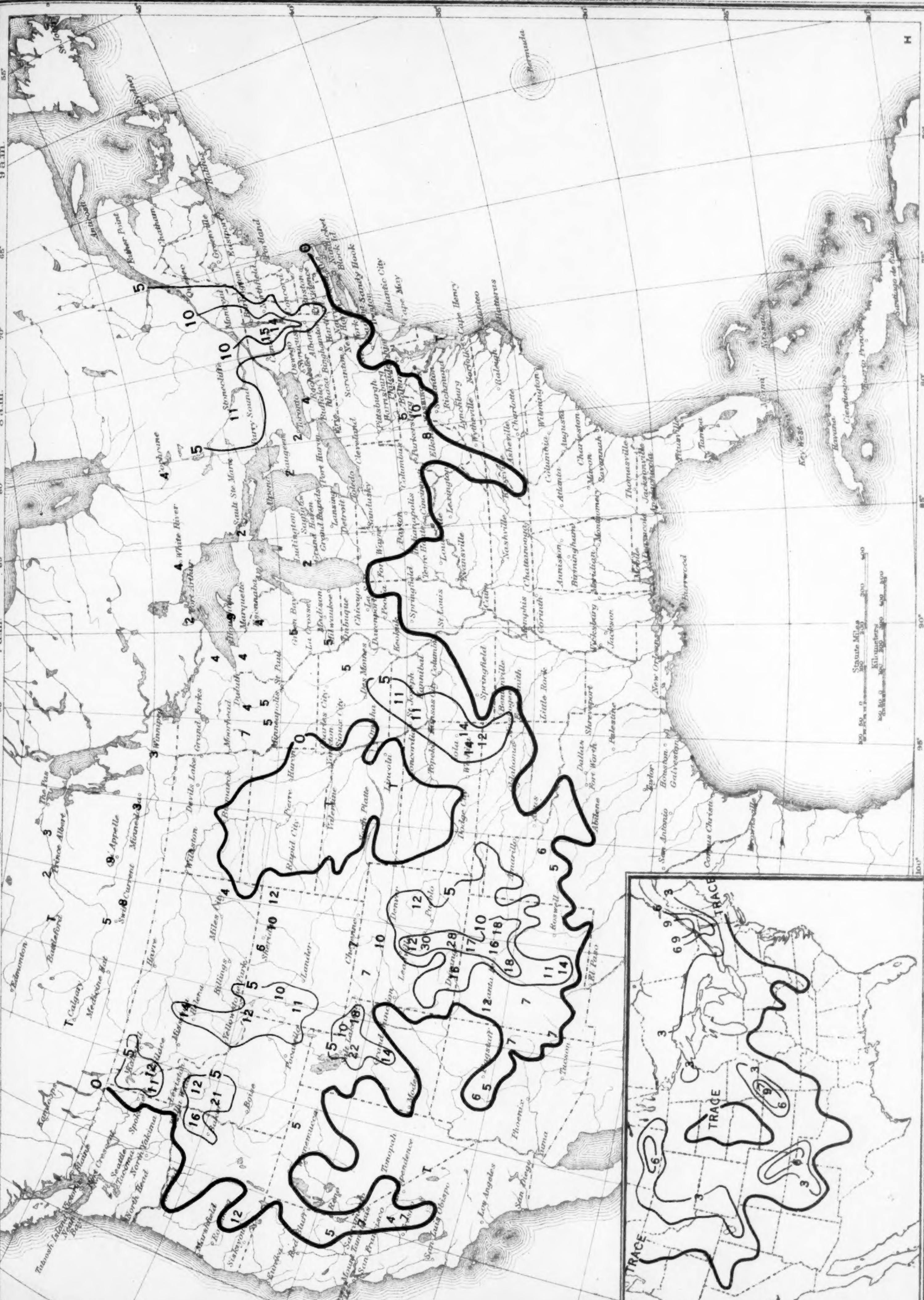


Chart VII. Total Snowfall, Inches, November, 1923. (Inset) Depth of Snow on Ground at end of Month.

Chart VIII. Weather Map of North Atlantic Ocean, November 23, 1923.
(Plotted by F. A. Young.)

Chart VIII. Weather Map of North Atlantic Ocean, November 23, 1923.
(Plotted by F. A. Young.)

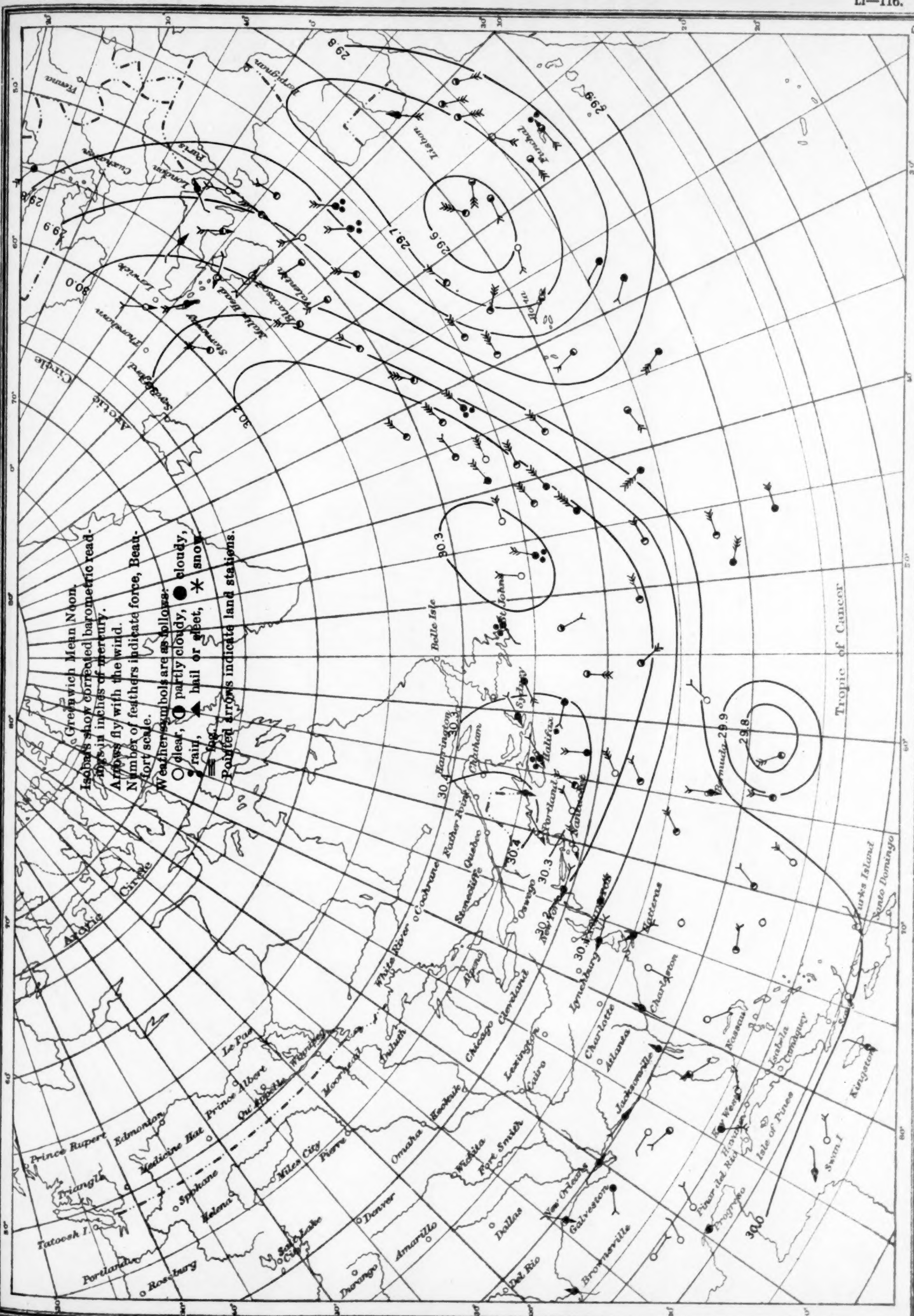


Chart IX. Weather Map of North Atlantic Ocean, November 24, 1923.
(Plotted by F. A. Young.)

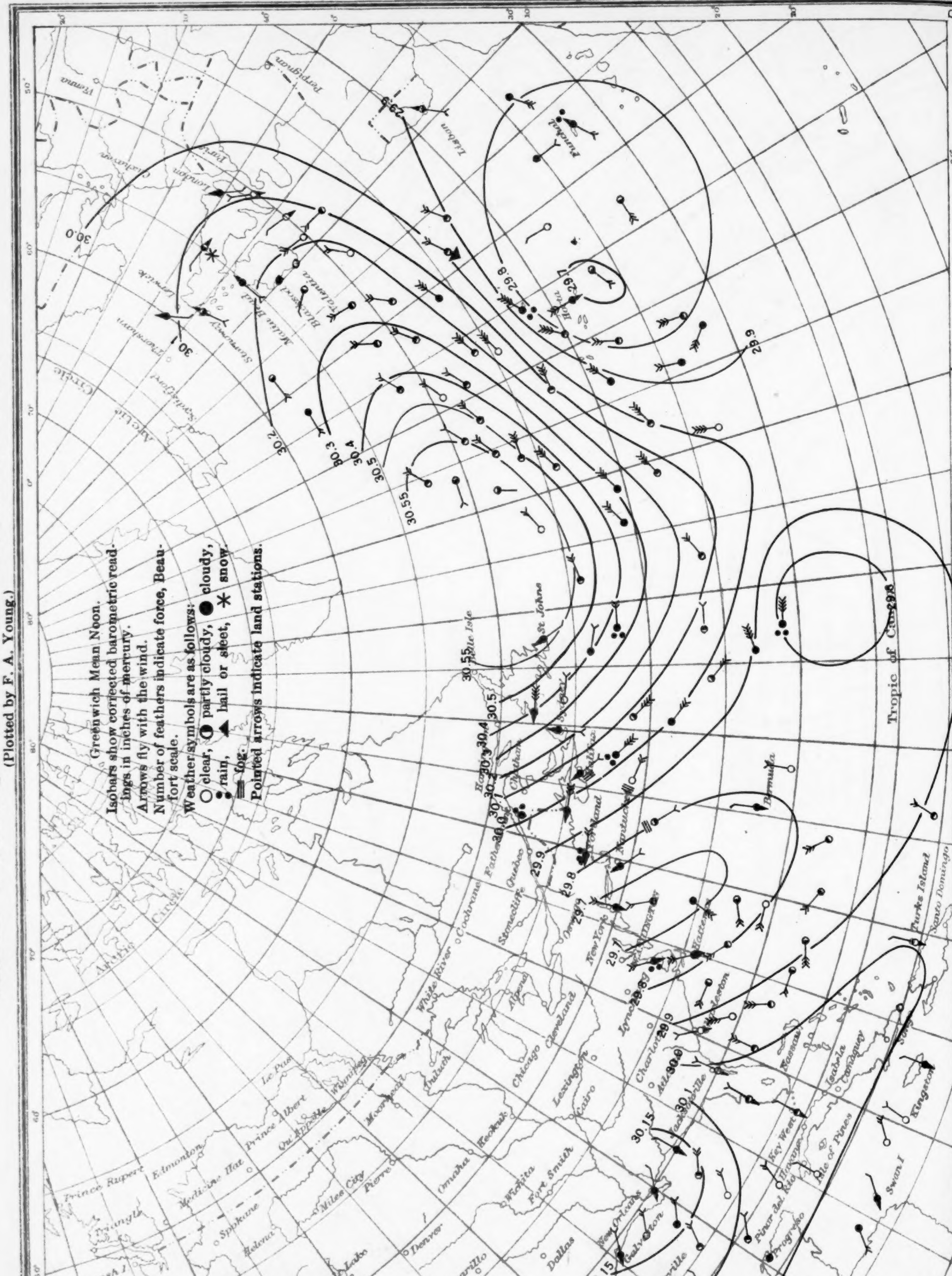


Chart X. Weather Map of North Atlantic Ocean, November 25, 1923.
(Plotted by F. A. Young.)

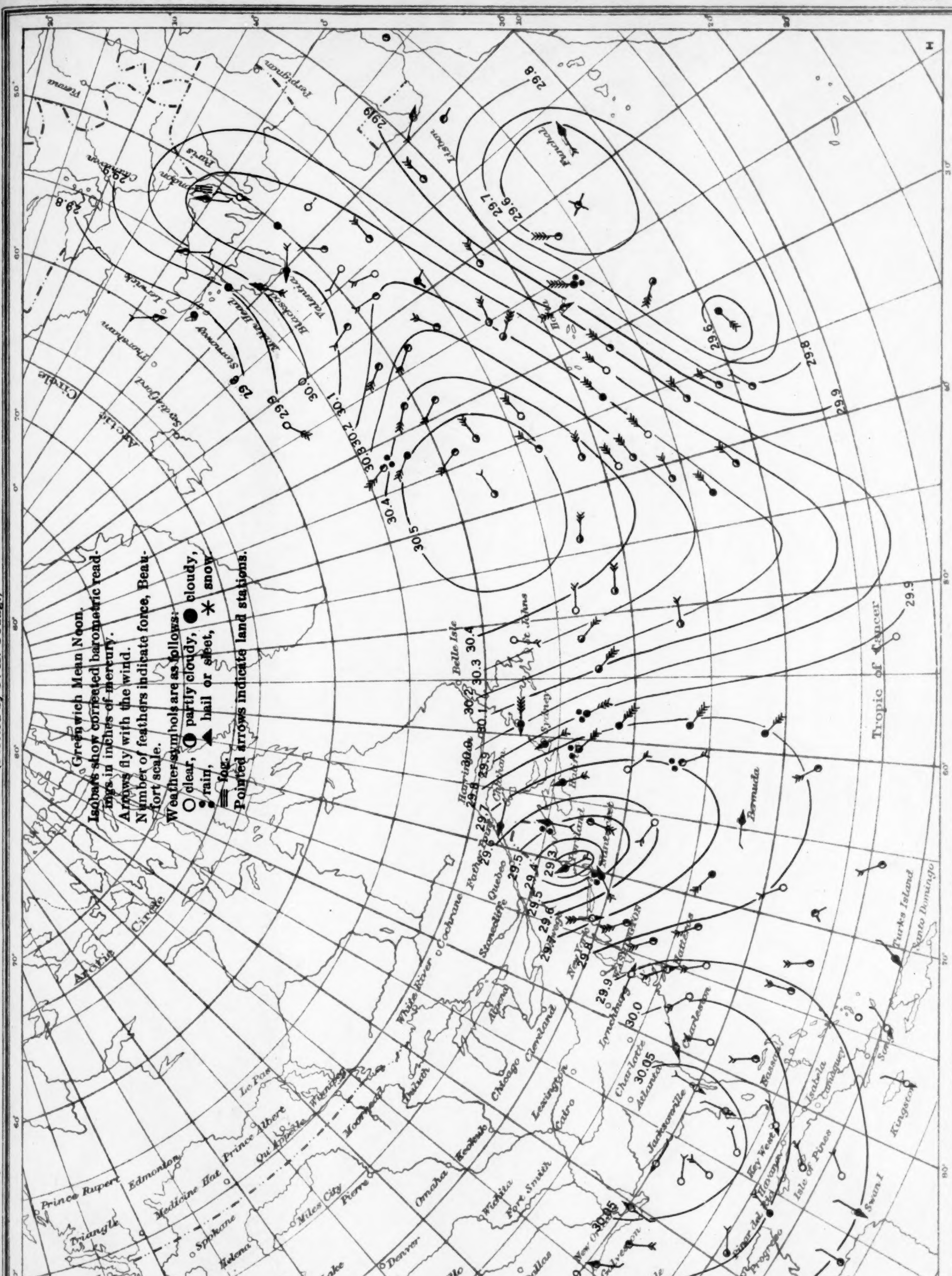
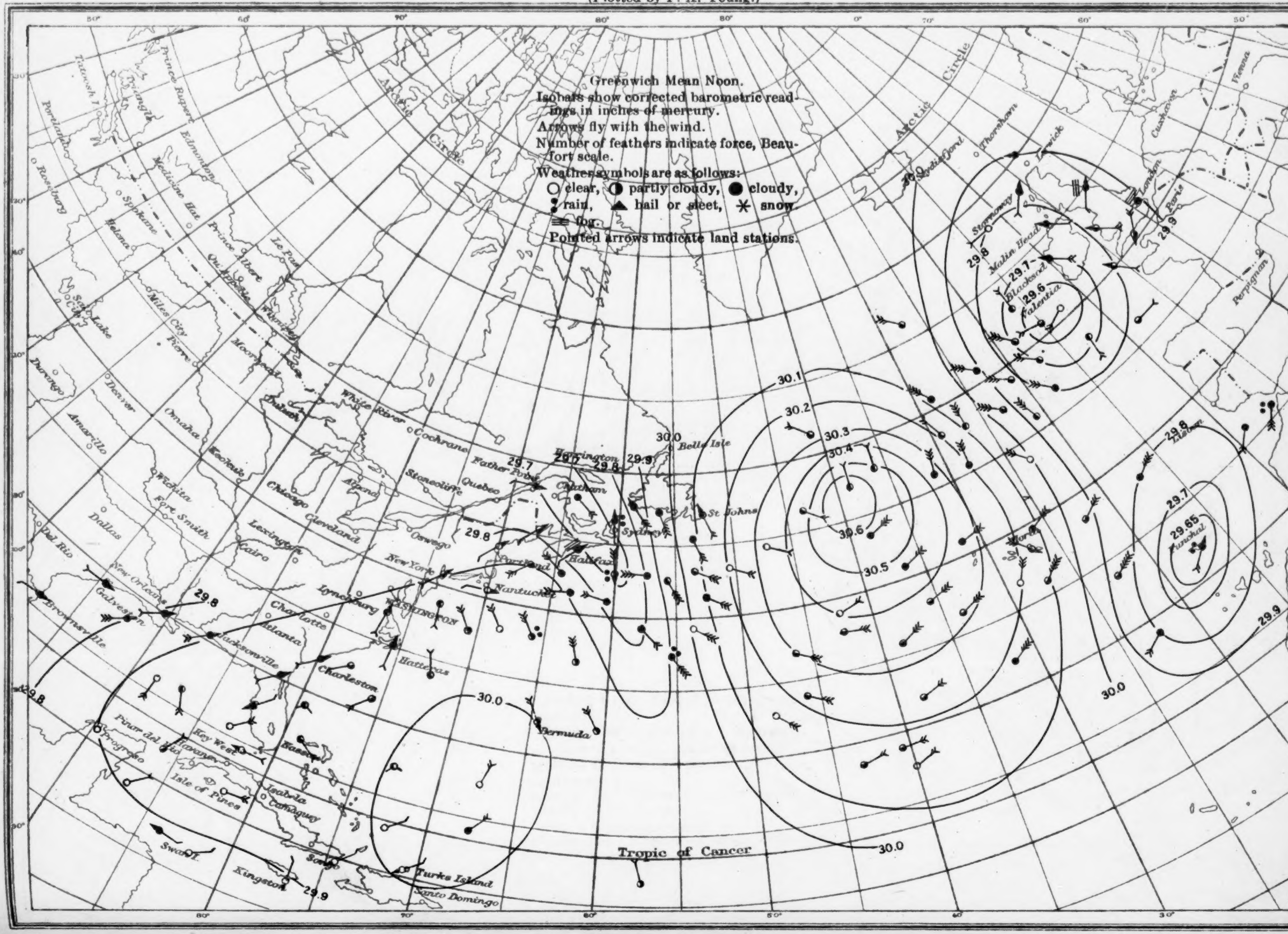


Chart X. Weather Map of North Atlantic Ocean, November 25, 1923.
(Plotted by F. A. Young.)

Chart XI. Weather Map of North Atlantic Ocean, November 26, 1923.

(Plotted by F. A. Young.)



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